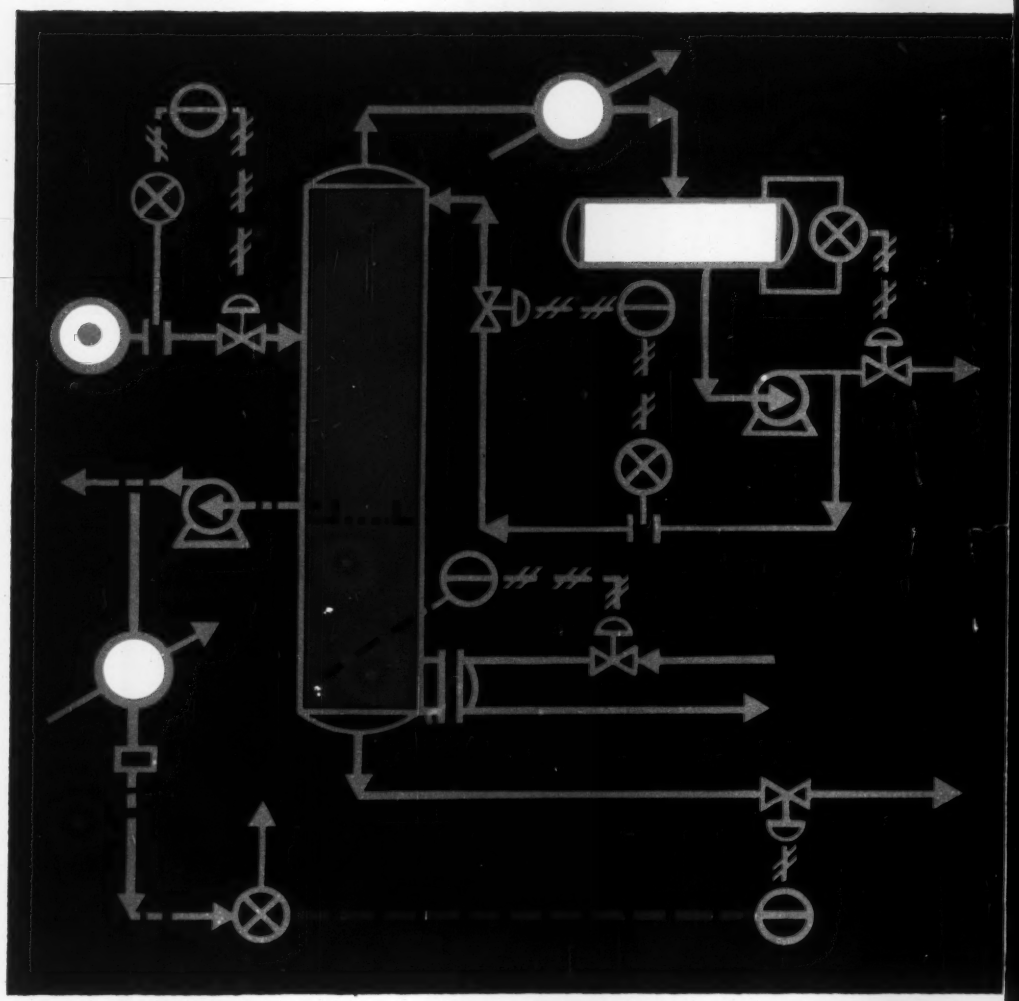
INSTRUMENTS AND CONTROL SYSTEMS

INCLUDING: INSTRUMENT MANUFACTURING • JOURNAL OF THE SCMA • SIMULATION COUNCIL NEWSLETTER



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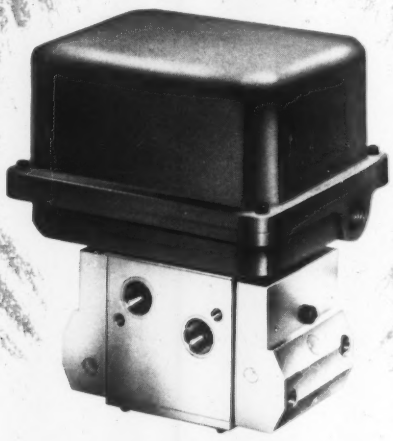
GPE Controls, Inc. presents an outstanding new advance in industrial automatic controls...the Rotojet® series of **electro-hydraulic servo valves.** Electrical input specifications include all ranges in current use. Total hysteresis is less than 0.2%. Single-stage output of 4½ g.p.m. at 1000 p.s.i. matches or exceeds most 2-stage units. Frequency response is 32 c.p.s. No filtration necessary. Guaranteed reliability at lowest cost.



GPE Controls | A GENERAL PRECISION COMPANY

Write for descriptive literature

GPE Controls, Inc. (formerly Askania Regulator Company)
240 East Ontario Street • Chicago 11, Illinois

A Subsidiary of GENERAL PRECISION EQUIPMENT CORPORATION

For more information circle 1 on inquiry card.

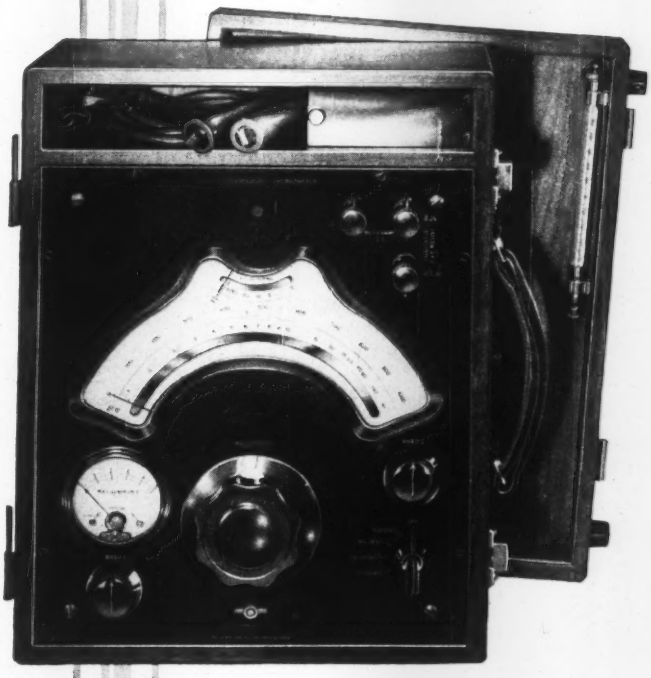
AN ACCURATE, PORTABLE, MULTI-FUNCTION INSTRUMENT

THE LEWIS *PORTABLE* TEST POTENTIOMETER

for Service Testing Exhaust Temperature Measuring Systems

Developed for use by field service engineers of a leading engine manufacturer, the Model 13P05 Test Potentiometer has proven its serviceability in desert heat and arctic cold at maintenance bases on many points of the globe.

FOUR PRECISION INSTRUMENTS IN ONE!



Model 13P05

A PYROMETER-POTENTIOMETER
for measuring exhaust thermocouple temperatures that is truly portable with a sturdy pivoted galvanometer and without a standard cell. Accurate automatic electrically operated cold junction compensation permits this instrument to be used in ambient temperatures from below freezing to plus 120°F. Mirror scales with precise hand-drawn graduations and knife edge pointers insure accurate readings from zero to 1000 degrees Centigrade.

A LOW RANGE OHM-METER
with a widely spaced, hand drawn scale for checking the resistance of leads, thermocouples and balancing resistors to insure correct adjustment to match external resistance requirements of exhaust temperature indicators, either eight or twenty-two ohms.

A KILO-OHM METER,
energized by a 67½ volt battery for checking insulation resistance of lead-wires and thermocouples. Due to the potential applied, this circuit is more effective in detecting flaws than conventional ohm meters. A hand-drawn scale is clearly marked in kilo ohms resistance.

A THERMOMETER TESTER
for precise scale error checks of exhaust temperature indicators having either eight or twenty-two ohms external resistance. A controlled power supply energizes the indicator under test, through the correct series resistance, and the zero to 1000°C temperature scale is used as a reference standard. Recommended for use in adjusting exhaust indicators in accordance with ambient temperature, with power applied for 700°C, through the proper resistance. A liquid-in-glass thermometer and flexible test leads are supplied with each instrument.

For dependable maintenance, use test equipment made by the manufacturer of the components to be checked.

LEWIS ENGINEERING CO.

NAUGATUCK, CONNECTICUT

For more information circle **2** on inquiry card.

SENSITIVE RESEARCH

NEW AC-DC VOLT-AMP-MILLIAMMETER

LABORATORY STANDARD

Model THACH

See it Demonstrated
New York IRE Show
Booth 3410-12

NOW PUSH-BUTTON CONTROLLED FOR MULTI-POINT SELF-CHECKING!

READ OUT AND 100% 80% 60% 40% 20%
TRANSIT |<—— SELF CHECK POINTS ——>|

THIS NEW SRIC *SELF-CHECKING* AC-DC LABORATORY STANDARD—with its own "Piggy Back" Primary Standards Laboratory—not only checks its full scale accuracy, but also certifies the linearity of its deflection to .1 %.

The *NEW* Model THACH is not only a wide range, AC-DC, direct reading portable instrument, but also a very precise transfer standard. It responds to true RMS and is equally accurate on AC or DC. The *NEW* multipoint Self-Checking system is simple to use. By merely depressing a push button and nulling an internal galvanometer, direct certification of the instrument's scale may be made on the job.

There is no electrical indicating instrument of the thermocouple type available today with the accuracy, versatility and RELIABILITY of the new push button controlled, multipoint *Self-Checking* Model THACH.

MODEL: THACH
TYPE: Thermocouple D'Arsonval
ACCURACY: .2 of 1% of Full Scale
AVAILABILITY:
SCALES: Hand-drawn, Mirrored 6.3" length
SENSITIVITY: 100 ohms per volt
FREQUENCY: DC to 4000 cycles

RANGES
Combination 1-a: 0-10/20/50/100/200/300/1000ma. 2/5 amps. 0-1/2/5/10/20/50/100/200/300/1000 v.
Combination 2-a: 0-15/30/75/150/300/750 ma. & 1.5/3 amps. 0-1.5/3/7.5/15/30/75/150/300/750 v.

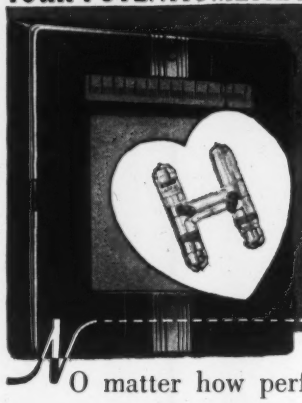
Diamond Pivoted of cow/sel

SENSITIVE RESEARCH INSTRUMENT CORPORATION
NEW ROCHELLE, N.Y.

Symbol of Quality

For more information circle **3** on inquiry card.

YOUR POTENTIOMETRIC INSTRUMENTS HAVE A HEART TOO!



NO matter how perfect otherwise, the human organism isn't much good without a dependable heart. The same is true of your automatic temperature and pH control instruments.

The "heart" of most such instruments for the past quarter century has been the Eplab Standard Cell. It is a "yardstick" for translation of voltage to temperature or pH. The first American commercial cell of its type, constantly improved by research, it is "as standard as sterling".

Get ACCURATE temperature or pH control with potentiometers and make sure the standard cells are EPLAB.

The Eppley Laboratory, Inc. 2 Sheffield Ave., Newport, R. I.

EPLAB *Standard* CELLS
FOR POTENTIOMETRIC INSTRUMENTS
"As Standard as Sterling"

For more information circle **4** on inquiry card.

INSTRUMENTS AND CONTROL SYSTEMS

Formerly INSTRUMENTS and AUTOMATION

FEBRUARY 1959

VOLUME 32 NUMBER 2

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EDITORIAL

Our Function and Field, 225

CHANGING a name to better describe a purpose

Report On Public High-School Course In Modern Engineering Physics, 225

ACADEMIC, vocational and industrial leaders join forces to devise a unique course in Modern Engineering Physics, emphasizing instrumentation.

FEATURE ARTICLES

Characteristics of Proportional-Speed Floating Action, 237

WERNER G. HOLZBOCK—knowledge of the characteristics of proportional-speed floating action can help to determine its suitability for control of a specific process. A hydraulic controller serves to illustrate this process action; the conclusions are applicable to other controllers with equal action.

Process Control Systems, 241

FRED D. MARTON—beginning a new series. Included are: glass feeder temperature control; single-element pilot-operated feedwater control; three-element feedwater control for boiler; arc furnace control; slasher cylinder temperature control; process refractometer controls ortho-xylene concentration in xylene fractionating operation.

Automatic Air Control For Fermentation Process, 244

H. F. BOTTCHER—air pressure control is key to uninterrupted fermentation growth of "miracle drugs" streptomycin, penicillin and mycostatin.

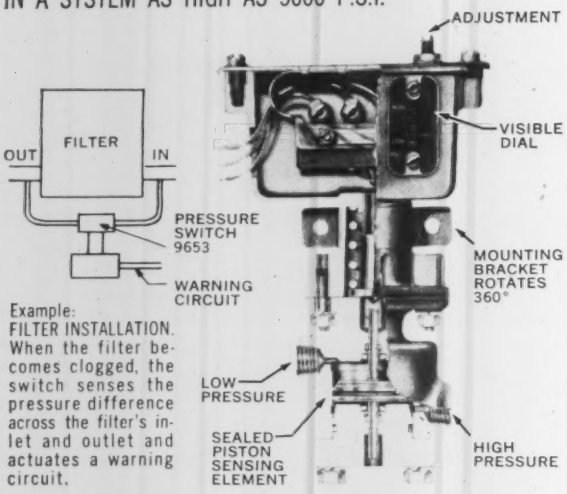
Response of Electric Valve Actuators, 246

RESPONSE of combination valve actuators was presented in our September and October (1958) issues. We continue with response data for electric valve actuators.

Continued on page 166

NEW PRESSURE DIFFERENCE SWITCH

SENSES A LOW DIFFERENCE OF 10 P.S.I. EVEN IN A SYSTEM AS HIGH AS 5000 P.S.I.



Example: FILTER INSTALLATION. When the filter becomes clogged, the switch senses the pressure difference across the filter's inlet and outlet and actuates a warning circuit.

The new Model 9653 is constructed to sense a difference from 5 P.S.I. to 140 P.S.I. between two pressures. A sealed piston sensing element actuates an electric circuit on increasing or decreasing of a predetermined pressure difference. It is applicable to oil systems ranging from 50 P.S.I. to 6000 P.S.I. working pressure. A high proof pressure rating of 9000 P.S.I. is your protection against damage from surges and shock loads. Field setting is simplified by means of an external adjustment screw and visible dial.

WE BUILD IN	WE DON'T USE
RUGGEDNESS Can take surges— (High proof pressures) Continuous operation— (Millions of cycles) No sticking— (in dirty fluid)	 **LINKAGES & BEARINGS** Which wear quickly—(cause settings to drift and switch to fail).
LABOR & MATERIAL SAVINGS No return drain piping— (Sealed piston) Mounts where convenient (Operates in any position, Not sensitive to vibration)	 **UNSEALED PISTONS** Which add to your installation cost (return piping). Are critical to dirt— (pistons get stuck).

Ask for new pressure switch handbook and catalog '59-'60

PRESSURE SWITCH DIVISION

Barksdale valves

5125 ALCOA AVENUE, LOS ANGELES 58, CALIFORNIA

For more information circle 5 on inquiry card.

INSTRUMENTS AND CONTROL SYSTEMS

VOL. 32 NO. 2 • FEBRUARY, 1959

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THE SOUTHERN CALIFORNIA METER ASSOCIATION

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PREVIEW of program scheduled for this year

THE SIMULATION COUNCIL NEWSLETTER

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ALL TRANSISTOR

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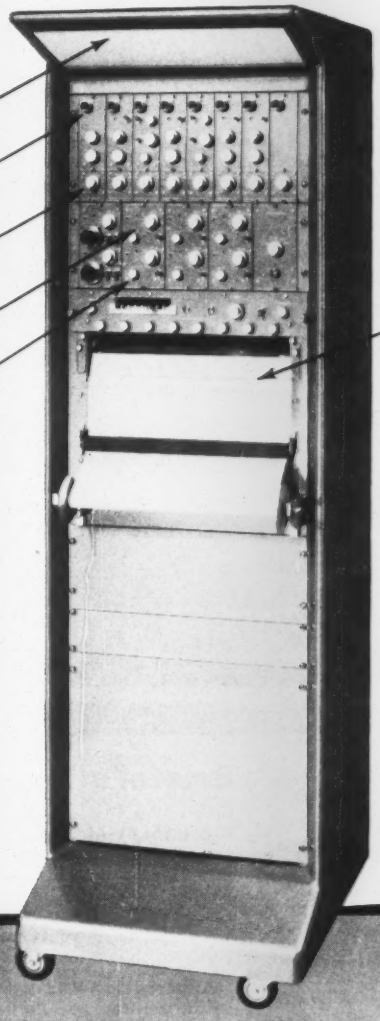
the most versatile . . . most sensitive direct writing unit available



Illuminated canopy

Type 9800 series input couplers provide all input, control and balance functions. Input available both front and rear.

Type 481 Preamplifier provides sensitivities from one microvolt to 5 volts per mm.

Type 482 power amplifiers—may be used without preamplifiers for up to 10 mv/cm sensitivity

Zero suppression control

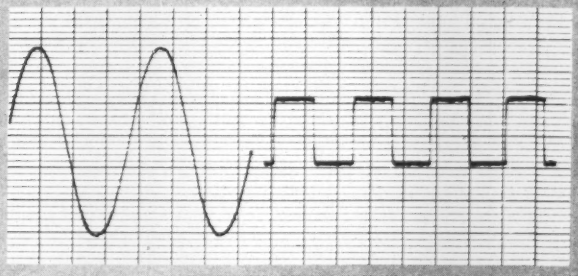
504-A paper drive—speeds from 1 to 250 mm/sec. Electrical speed shift 1 to 250 mm per minute available. Zero weave high precision drive, 850 ft. capacity (heat or electric) 1500 ft. (ink). Front loading, with full unobstructed record visible from front.

Combining all these features...

- *stable d-c sensitivity of one microvolt per mm*
- *true differential input*
- *high input impedance*
- *response to beyond 150 cps.*
- *reluctance, differential transformer, strain gage with a-c or d-c excitation, thermocouples, etc., used with all preamplifiers*
- *deflection time less than 1.5 milliseconds (2.5 ms with preamplifiers)*
- *fixed precision calibration*
- *instant warm-up*
- *precision source for d-c and 400 cycle excitation, self-contained*
- *zero suppression, twenty times full scale, both directions*

Thanks for your patience in awaiting deliveries of the Type R. Schedules were temporarily disrupted by the large volume of orders received for this radically new instrument. We are now in our new plant, with 300% more space, and are rapidly increasing production capacity. Deliveries will soon be on a current basis.

FULL SCALE, UNRETOUCHED CHARTS PRODUCED ON THE TYPE R DYNOGRAPH



EXTREME SENSITIVITY

10 Microvolt RMS Sine Wave **Ten Microvolt D-C Square Wave**

Four recording media. Heat or electric rectilinear—ink or electric curvilinear. Readily convertible.

All these features . . . plus 8 channels in only 35" of rack space. Whatever your application for direct writing records . . . you should investigate the ability of the Offner Type R Dynograph to do the job *better* and more *simply*. Using transistor circuits* developed and tested for over three years in thousands of channels of Offner equipment, the Type R Dynograph has already proved its superiority in practically every respect to *any other* direct writing oscillograph. Write on your company letterhead for literature giving details and specifications.

**Patents granted and pending*

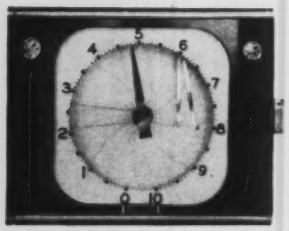
OFFNER ELECTRONICS INC.

3910 River Road, Schiller Park, Ill.
(Suburb of Chicago)

For more information circle 6 on inquiry card.

Bristol's 7-point coast-to-coast field service

Helps you from the time you start thinking instruments – through installation – for as long as the job requires



A Bristol Field Engineer is the man to call when you first start thinking about instrumentation. Located in a nearby Bristol office (they blanket the U.S. and Canada) he calls at your plant to assist you in planning your proposed installation. No obligation.

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Periodic Check-up Service at regular intervals is also available.

Bristol's Instrumentation Schools for customer engineers help train your own technicians in instrument operation and maintenance.

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Fast Parts Service is assured by the Bristol practice of stocking service parts that may be needed in emergencies in all 38 Branch offices. You get fast action from a near-by source.

These big extras you get with Bristol instruments are good reasons—over and above outstanding basic instrument quality—why every Bristol installation gives such high accuracy and precision performance over an extremely long service life. To find out more about Bristol instruments or service, write: The Bristol Company, 113 Bristol Road, Waterbury 20, Conn. B.17

BRISTOL TRAIL-BLAZERS IN PROCESS AUTOMATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more information circle **7** on inquiry card.

to the editor

Editor, I&A:

In reading the column "Letters to the Editor" in the November 1958 issue under "Reader Inquiries A-349" a company inquires as to a tester to determine magnetic properties of ink strip on paper, also cross section and ink film thickness within 0.005 inch.

There is a possibility that the "Oerstedmeter Model F. M.-201" having a sensitivity of 10^{-5} gauss/scale division would be capable of detecting the magnetic properties of the ink strip. The Magnaflux Corporation, Chicago, Illinois are the distributors for this instrument.

Relative to the ink film thickness I would suggest contacting Mr. S. U. Lieber, Sales Manager, Unit Process Assemblies, Incorporated, 61 East 4th Street, New York 3, New York. This company manufactures the "Dermitron Thickness Tester" used for measuring the thickness of conductive and non-conductive film on metalic or non-metalic surfaces.

The Decker Aviation Corporation, 1361 Frankford Avenue, Philadelphia 25, Pennsylvania manufacture a capacitance micrometer that may be capable of measuring the ink film thickness should the paper have a constant thickness.

R. C. Hollobaugh,
Westinghouse Electric
Pittsburgh, Penna.

Editor, I&A:

We note from your feature on combination valve actuators in the September issue of INSTRUMENTS AND AUTOMATION that there is considerable difference of opinion among manufacturers on conditions under which they obtain response information. You would be performing a great service to the instrument industry were you to compile a standard set of conditions and perhaps draw-up a standard method of expressing dynamic response of valve actuators. Although these might initially be arbitarary and even subject to some criticism, it would be a great forward step.

L. J. Kaiser
Bailey Meter Co.
Cleveland, Ohio

We are forwarding this comment to the IRD division of ASME, the Fluid Controls Institute, and the ISA —let's see who acts fastest!

microflex
RESET TIMER
20 turn dial provides
EXACT timing for
industrial processes
The double micrometer dial permits 1200 accurate, visual settings over entire dial range. Set this timer for 12 minutes 6 seconds or any other exact time setting required.

Savings

- Large 15 ampere contacts eliminate additional load relays.
- Stop down time with plug-in components for fast timer replacement.

Flexibility

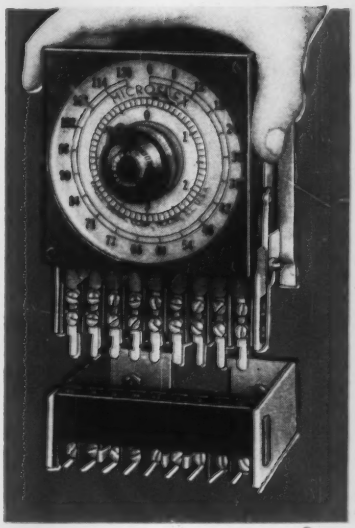
- Easy to set dial whether short or long timing.
- Choice of 9 actions available for each of 3 contacts. Select operation required for your circuit.

Accuracy

- Set dial to exact time required. No guessing at numbers.
- Accurate repeatability insures uniform production.

Reliability

- Proven reliability in thousands of industrial processes for more than 25 years.



Install timer in seconds with optional plug-in feature.

EAGLE SIGNAL CORPORATION
Industrial Timers Division, Dept. IA-259
MOLINE, ILLINOIS

Please send FREE Bulletin 110 containing complete data on Microflex Reset Timers.

NAME AND TITLE

COMPANY

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CITY ZONE STATE

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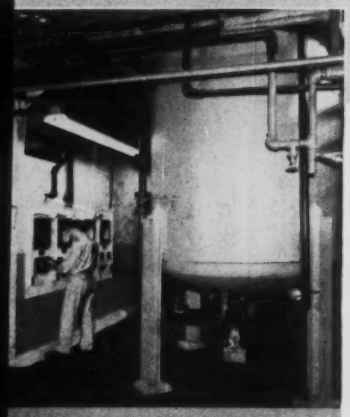
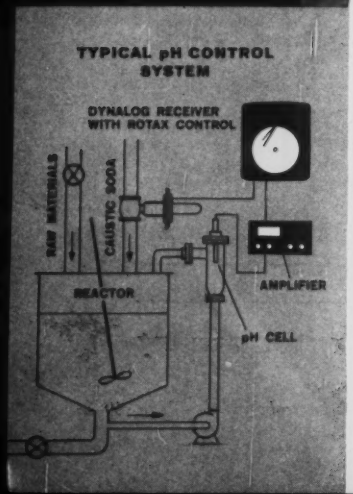




at Sika Chemical—

REACTORS CONTROLLED WITHIN 0.1 pH

by Foxboro **DYNALOG*** Recorder-Controllers

At Sika Chemical Corp., Passaic, N. J., control of pH in reactors is of vital concern in manufacturing "Plastimet," Sika's widely-used concrete densifying additive.

Sika finds Foxboro Dynalog Recorder-Controllers perfect for the job. Dynalog's smooth variable air capacitor (which replaces troublesome step-by-step slidewires) responds instantly to the smallest change in pH value. A Rotax on-off control unit then initiates addition of enough caustic soda to return reactor pH to set point.

Sika reports maintenance on their Dynalogs has been almost nil. One tube replaced in three years. No lubrication ...no cleaning...no dry cells to standardize or replace. "In fact," says process engineer Gordon Morrison, "we're so confident of Dynalog's performance that our reactors run right through the night—unattended."

Dynalog Electronic Recorders—Controllers—Indicators deliver accurate, sensitive, measurement not only of pH, but of dozens of other variables as well. Get full details by writing for Bulletin 20-10. **The Foxboro Company, 462 Norfolk Ave., Foxboro, Mass.**

*Reg. U.S. Pat. Off.

FOXBORO
REG. U.S. PAT. OFF.

DYNALOG ELECTRONIC INSTRUMENTS

For more information circle 9 on inquiry card.

Editor, I&A:

The article "Automatic Reader for Precision Balances" on page 1972 of your December, 1958 issue contains one error of fact. The first sentence of the section "Background Noise" (lower left hand corner of page 1974) contains the phrase "about 2 micro inches per minute." This phrase should read "about 2 thousandths of an inch per hour." We apologize for this error and would appreciate your noting the change in some future issue.

L. B. Macurdy
Chief, Mass Unit
Mass and Scale Section
National Bureau of Standards
Washington, D. C.

Editor, I&A:

Your editorial statement in Nov. *I&A* that computers are often used where a slide rule would suffice reminds me of the story about a physics professor who seldom accepted slide rule accuracy in favor of long-hand calculations. In a hurry at the conclusion of class one day, he grabbed his slide rule and rapidly proceeded with a few calculations which ended in 2^2. He carefully set this up on his rule, squinted at it to get an accurate reading and said, "Copy this answer before you leave students, and remember that this is only approximate —3.99."

This shows that the brain can be better than the slide rule, just as the slide rule can often serve better than an electronic computer.

John Grissom
Welex, Inc.
Houston 1, Texas

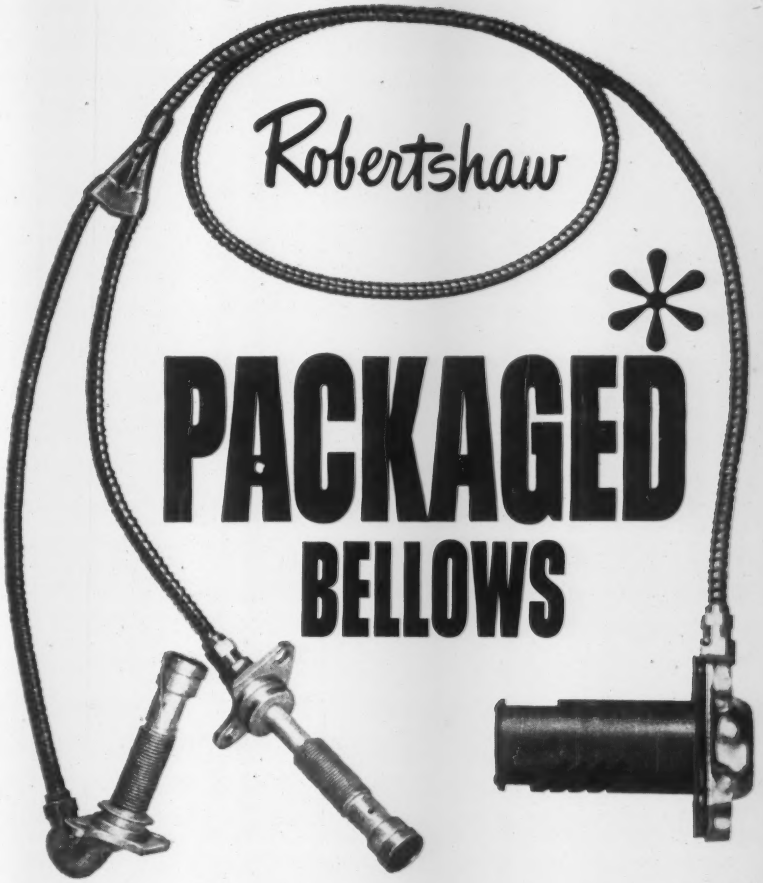
Another moral is that the brain is required even when using slide rules and computers.

Editor, I&A:

I am one of the subscribers of *INSTRUMENTS AND AUTOMATION*, but since I started this year I missed some of your early issues. Please send me a copy of January through June issues.

Jeff T. Ozeki
Cincinnati 20, Ohio

We can send you a list of articles, abstracts, and an editorial analysis—but the demand for every issue of 1958 has been so great that no back issues are available. Sorry. P.S.: Better hold on to your issues of *INSTRUMENTS and AUTOMATION*. With present demand, they might become collectors' items.



...why you save on custom-engineered "one-source" bellows and accessories

* It pays to specify seamless metal bellows *and all assembly components* as one "package"—designed as an integral unit . . . produced to one high standard of quality . . . tested under uniform procedures . . . and delivered already assembled.

Custom-engineered Robertshaw Packaged Bellows save handling, assembling, testing, incoming inspections and paper work in your plant. And you benefit from one source responsibility, no scattered deliveries and lowest possible unit costs.

Wide selection of bellows metals permits outstanding uniformity and stability under tough conditions of temperature, pressure, corrosion and vibration. Bellows sizes from subminiature ¼" O.D. up to several inches O.D.

Discuss your Packaged Bellows needs with a Robertshaw engineer . . . or get started right now by writing for Bellows Bulletin F-102.

Mr Controls

Robertshaw-Fulton
CONTROLS COMPANY

BRIDGEPORT THERMOSTAT DIVISION • Milford, Conn.

For more information circle **10** on inquiry card.

SR-4® LOAD CELL

MEASURE WEIGHT, THRUST AND LOAD THIS MODERN WAY

B-L-H SR-4 Load Cells offer a dependable, accurate way to measure weight, thrust and load. Rugged and compact, they operate accurately under widely diverse conditions and are used to measure jet and rocket engine thrust, to determine center of gravity, to weigh loads at rest or in motion, and to control batch and continuous processes. Output permits local or remote instrumentation . . . indicators, recorders, printers, etc.

Available with capacities of from 50 to 200,000 lb. (compression) or 50 to 100,000 lb. (tension or compression), standard SR-4 Load Cells may be furnished with calibration accuracies of either ±0.25% or ±0.10% of rated capacity, depending on your requirements. Special capacities and/or characteristics can be furnished on order.

SR-4 Load Cells use accurately-matched SR-4 Bonded Strain Gages to detect the minute dimension changes of a central load column under tension or compression. They are hermetically sealed, are unaffected by dust, grease, moisture, corrosive atmospheres, etc.

For more data on B-L-H SR-4 cells, write Dept. 7-B for a copy of Bulletin 4301. Or let us send a B-L-H man to see you at your convenience.

SR-4® LOAD CELL ADVANTAGES

- No moving parts
- High accuracy and repeatability
- Rugged, compact construction
- Long, economical service life

FIRST in force measurement

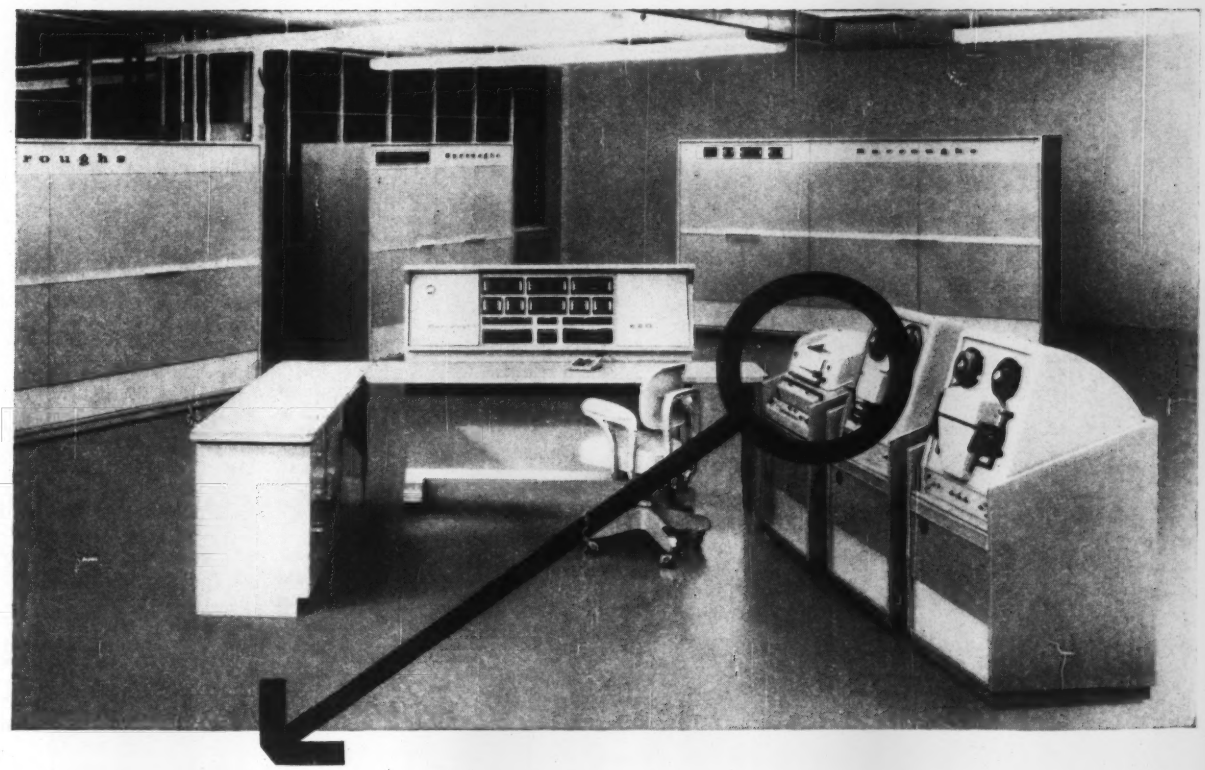
BALDWIN · LIMA · HAMILTON

Electronics & Instrumentation Division

Waltham, Mass.

SR-4® Strain Gages • Transducers • Testing Machines

For more information circle **11** on inquiry card.



Eight reasons why Burroughs chose Teletype Printer for the new 220

ElectroData Division of Burroughs Corporation made extensive tests and comparisons before choosing a supervisory and off-line printer for their new, high-speed electronic data processing system—the Burroughs 220.

Here are the eight reasons for choosing the Teletype Model 28 Printer:

1 Reliability. In actual test, the Teletype Model 28 Printer ran continuously . . . more than 20 times as long as other equipment tested.

2 Parallel Input. The Printer accepts parallel input information—desirable since the output from the data-processor is parallel.

3 Coding Flexibility. Type boxes used in the Model 28 Printer may be interchanged quickly and easily to suit a variety of code requirements. This feature is unique with Teletype.

Any code may be made to accomplish any non-printing function in the printer or to actuate a transfer contact—by a simple change in the Stunt Box (exclusive with Teletype).

4 Speed. The Model 28 Printer meets the speed requirement of 100 words per minute.

5 Readability. Quick reading of the copy is easier because type box moves across a stationary platen—rests out of the way between characters.

6 Tabulating. The Printer is equipped with a horizontal tab which is fast and adjustable. It has, also, an adjustable "Form-Out" for indexing printing on next printed form.

7 Appearance. The Teletype Model 28 Printer is housed in a well-designed, attractive cabinet.

8 Quiet Operation. Operating noises are reduced to a minimum by the sound absorbing cabinet enclosure.

More Information. The Model 28 Printer is one of several units in the all-new Model 28 line of Teletype equipment. If you would like more information on these new units, write to Teletype Corporation, Dept. 23-B, 4100 Fullerton Avenue, Chicago 39, Illinois.

TELETYPE®
CORPORATION
SUBSIDIARY OF *Western Electric Company* INC.

For more information circle **12** on inquiry card.

24-HOUR CONTROL... FOR ONE MINUTE'S PAY!

New Fulton Sylphon Series 1003 Regulators Provide On-Spot Control at Low Cost

● This new self-powered regulator is trouble-free, powerful and sensitive. Installation is easy and inexpensive. Large Sylphon® Bellows provides perfect stroke action for valves up to 4". Handles pressures up to 250 psi. Designed for extra-long life . . . and you can put it on your plant's "payroll" for round-the-clock control at a daily cost *less than your average employee's pay for one minute.*

NEW at no extra cost

- **Teflon Chevron lifetime valve stem packing — no service needed**
- **Monel valve stem super-finished to prevent sticking**
- **"Quick-Detach" stem fitting for easy valve removal**
- **Single-seated "MA" valve for "dead end" service**
- **Over-temperature assembly prevents regulator damage**

GET THE FULL STORY OF LOW-COST TEMPERATURE CONTROL IN BULLETIN D-CL

Mr. Controls®

Robertshaw-Fulton CONTROLS COMPANY

FULTON SYLPHON DIVISION • Knoxville 1, Tenn.

For more information circle **13** on inquiry card.

Editor, I&A:

There have been many pleasant experiences following your publication of parts of my Cleveland talk on the editorial page of the June issue of *Instruments and Automation.* Other events prevented me from getting to the Automation Show in New York where I hoped to meet you personally. From all the reports you had a most successful show and I hope you will have a long series of satisfactory exhibits in the years ahead.

We are still emphasizing the importance of instruments in this area and have organized the Springfield Science Fair in affiliation with the National Science Fair. A country-wide assembly of best student projects comes into display at Hartford, Connecticut in April. The theme of our own efforts will emphasize the advancement of the sensitivities of our students by teaching them to make and employ instruments which increase the significance of their observations in any field.

I gave your name to Mr. John B. Davis, Executive Secretary of the New England School Development Council, an organization of 140 New England school systems working in cooperation with the Harvard Graduate School of Education. Mr. Davis inquired of me about the development of instruction in automation and I was happy to refer him to your pioneer efforts in Pittsburgh.

M. Marcus Kiley
Deputy Superintendent
Public Schools of
Spring, Mass.

Editor, I&A:

The articles in November *I&A* were beautiful. The cover was superb, and we were flooded with inquiries of good high caliber. It seems that even though we felt that a great number of people knew about our instruments, we still were pretty well unknown.

H. Joseph Gerber
The Gerber Scientific Instrument Co.
Hartford, Conn.

But not any more!

Editor, I&A:

Your November 1958 issue was good—good!

James L. McFadden
Gow-Mac Instrument Co.
Madison, N. J.

Editor, I&A:

[Referring to the May *I&A* article on "Process Characteristic Analyzer"] Hasn't this been available before? The specific hardware wasn't designated as a "Process Characteristic Analyzer" but it served the purpose. I am reminded of the paper Lyman Allen, Jr. wrote for ASME/IRD on the Process Characteristic Analysis of a fractional distillation column using an ordinary Controller and a sort of cross-correlation plot of temp *vs* flow (I believe). Ziegler worked on it with him. But don't get me wrong. I think you have something here. We can use more Quarie-type thinkers. It's not a new concept, merely a new name.

Robert L. Galley
Consulting Engineer
Woodland Hills, Calif.

A digital computer is not a "new concept" either. You can do the same thing manually—but the automatic device does it faster, better, safer, and cheaper in the long run!

reader inquiries

Microammeters

Camera distributor seeks source of supply for microammeters in the price range of $10 to $30. A-374

Gasoline-Pump Type Meters

Company dealing with steam specialties desires information on remote electric counters metering flow with numerical readout for varying prices in dollars and cents, and possibly printed record of volume, price factor, price in dollars and cents, sub-total, and total for year. Reset required for counting period and year. A-375

Needles for Needle Valves

Purchasing agent of instrument company wishes to buy needles for needle valves. A-376

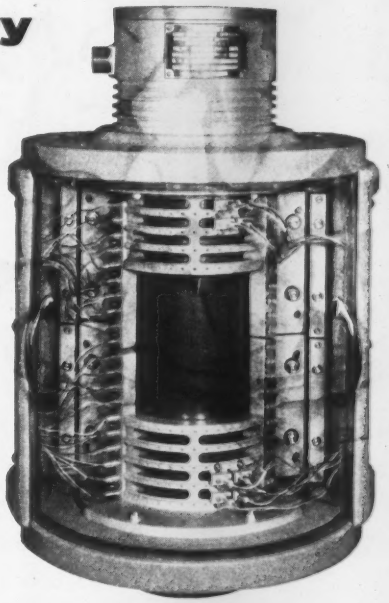
Float Switches, Air-Volume Controls

Instrument company in Ireland wishes to contact manufacturers of float switches, also air volume controls. A-377

Instrument Rental Service

Test engineer of railroad company wishes to rent recording thermometers, pyrometers, pressure gages, flowmeters, voltmeters, etc. A-378

Improve Your Memory



with a standard multiple purpose off-the-shelf drum

The 512-A Bryant general purpose magnetic storage drum meets the exacting requirements of a production component, yet has the versatility necessary for laboratory work. This standard 5" dia. x 12" long drum is stocked for immediate shipment, complete with standard components such as general storage brackets, recirculating register brackets and magnetic read record heads. Its low price reflects the benefits of Bryant's 25 years' experience in the efficient design and production of high speed precision spindles.

Features:

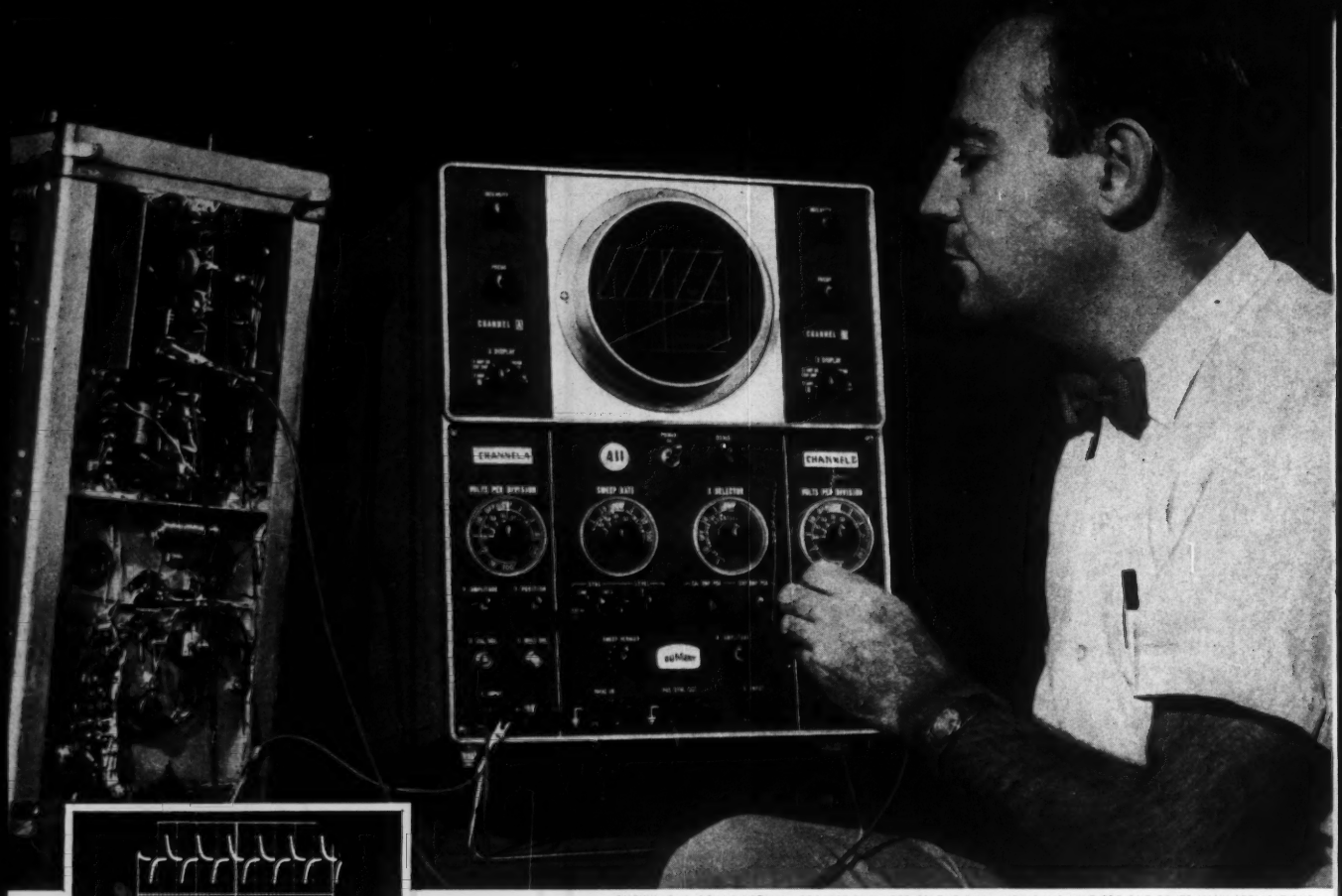
- Guaranteed accuracy of drum run-out, .00010" T. I. R. or less
- Integral drive – Bryant precision motor (1200 to 12,000 R. P. M.)
- Capacities to 625,000 bits
- Accommodates up to 240 magnetic read record heads
- High density ground magnetic oxide coating
- Super-precision ball bearing suspension
- Vertical mounting for trouble free operation

Special Models: If your storage requirements cannot be handled by standard units, Bryant will assist you in the design and manufacture of custom-made drums. Speeds from 60 to 120,000 R. P. M. can be attained, with frequencies from 20 C. P. S. to 5 M. C. Sizes can range from 2" to 20" diameter, with storage up to 6,000,000 bits. Units include Bryant-built integral motors with ball or air bearings. Write for Model 512-A booklet, or for special information.

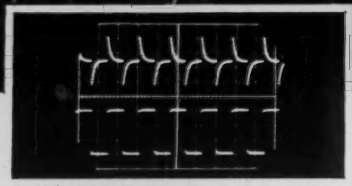
Remember . . . you can't beat a Bryant drum!

BRYANT COMPUTER PRODUCTS DIVISION
BRYANT CHUCKING GRINDER CO.
P. O. Box 620-I, Springfield, Vermont, U.S.A.

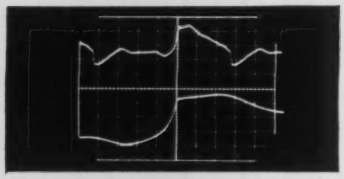
For more information circle **14** on inquiry card.



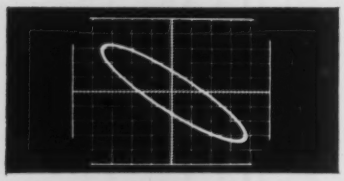
SHOWN IS M. SCHNEIDERMAN, PROJECT ENGINEER ON THE DUAL, USING HIS UNIT FOR ONE OF ITS MANY APPLICATIONS.



DUAL-BEAM DISPLAY — Outputs of the ultra-high-sensitivity deflection amplifiers of each channel are applied on identical time bases for clear and accurate comparison.



EXPANDED TIME BASE DISPLAY — With a signal from one channel applied on a calibrated time base, that same signal (or a different one) may be displayed on an expanded time base through the other channel. X5 expansion is available on either channel.



ULTRA-HIGH-SENSITIVITY X-Y PLOTTING — At the turn of a front panel control, outputs of the two deflection amplifiers may be applied to the X-Y axes of one channel, providing the most sensitive identical X-Y amplifier scope available. In this condition there is still an unused channel to display either of the above signals against time.

WRITE FOR COMPLETE INFORMATION

AN ULTRA-HIGH SENSITIVITY DUAL-BEAM OSCILLOSCOPE OFFERING A GREAT VARIETY OF DISPLAYS

The Du Mont DUAL (Type 411) is a dual-beam oscilloscope of high sensitivity embodying an unusually varied selection of displays. It is a true dual-beam scope employing a multi-gun cathode-ray tube. Each vertical channel may be operated independently of the other, with complete amplitude calibration facilities on both.

BRIEF SPECIFICATIONS

SENSITIVITY (both channels identical): Through amplifier, ac or dc—100 uvolts/major scale division (1 mv full scale).

FREQUENCY RESPONSE: dc to 100 kc

SYNCHRONIZATION SOURCE: External, power line or internal pickoff from either Y-amplifier; syncs on either polarity.

SWEEP SPEEDS: Calibrated sweeps, 19 fixed steps ranging from 1 sec/cm to 1 usec/cm in a 1-2-5 sequence. Uncalibrated sweep (through amplifier), continuously variable from 1 sec/cm to 2 usec/cm.

SWEEP EXPANSION: Up to five times full scale on either channel independently with no on-screen distortion.

VERTICAL EXPANSION: Up to three time full scale.

VOLTS/DIVISION RANGES: VOLTS PER DIVISION switch settings .001, .01, .1, 1 and 10 with MULTIPLIER switch settings x .1, x .5, x 1, x 2, and x 5.

POWER SOURCE: 115/230 volts ± 10%, single phase 50 — 400 cps. Transistorized heater regulation on all critical amplifier circuits.

CATHODE-RAY TUBE: 5 ARP-, operating at 2500 volts.

MECHANICAL: Size: Type 411, 17½" x 13½" x 23¼" overall. Type 411-R, 17½" x 19" (panel), 13½" (behind panel) x 21", 1¾" protrusion in front of panel. Weight approx. 70 pounds.

HAND-CRAFTED WIRING THROUGHOUT

$995.00

PRICE: Type 411 & 411-R
F.O.B. Clifton, N.J., U.S.A.

DU MONT® 411

INSTRUMENT DIVISION
Allen B. Du Mont Laboratories, Inc. • 760 Bloomfield Ave., Clifton, N. J.

For more information circle **15** on inquiry card.

Announcing Epsco's **NEW**

DVOM

A MAJOR ADVANCE IN DIGITAL VOLT-OHM METERS

⅓ ACTUAL SIZE

FULLY TRANSISTORIZED

No Stepping Switches • No Relays

● **VERSATILE** accurately measures both resistances and AC-DC voltages and counts external events, too! Directly drives printers, punches and memory storage units and can be directly used as a bi-directional telemeter.

● **FAST** less than 2 millisecond reading time . . . up to 100 completely independent measurements per second for any system use.

● **EASY TO READ** in-line, in-plane visual display . . . lamp life up to 10,000 hours . . . numerals 1⅛ inch high . . . automatic indication of polarity, decimal point and mode of operation

True dependability and versatility have at long last come to digital volt-ohm meters in EPSCO'S new DVOM. Fully transistorized . . . adjustment-free . . . no stepping switches or relays. Provides precise numerical measurement of AC-DC voltages, resistances . . . fast, accurate visual or printed quality control data . . . high-speed data acquisition for direct print-out or storage . . . remote indication and data transmission over a single line. Compact, lightweight, portable — also for rack-mounting. Write for Bulletin 95801, Epsco, Inc., Equipment Division, 588 Commonwealth Ave., Boston 15, Mass.; in the West: Epsco-West, 125 E. Orangethorpe Ave., Anaheim, California

DVOM price.....$1,475

Ask for a demonstration.

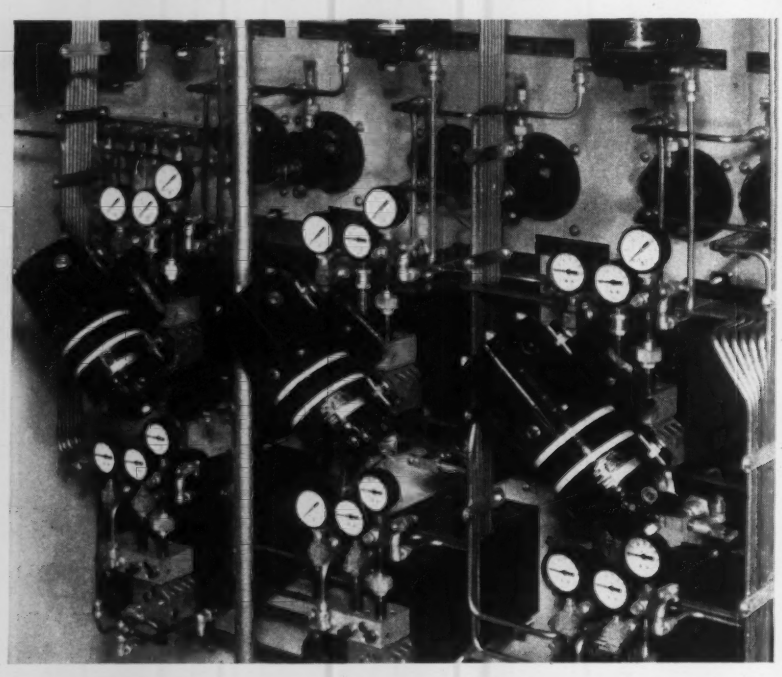
Epsco

First in data control

For more information circle **16** on inquiry card.

IMPERIAL Engineering and Data File

ENGINEERED TUBE FITTINGS — VALVES — TUBING TOOLS



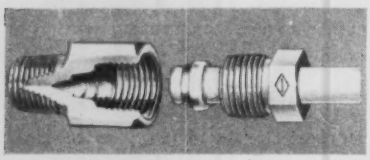
Leakproof connections quickly made with Hi-Duty tube fittings on Panellit control boards

Tube fittings that assemble to tubing fast and provide assurance against leaks are one of the top requirements for control boards.

That's why Panellit selected Imperial Hi-Duty fittings on this panel board used for automatically controling a variety of oil refinery processes.

Hi-Duty Fittings have a one-piece nut and sleeve. A joint is made simply by pushing tube into fitting and tightening nut. Sleeve shears off and becomes permanently attached to tube. One man can easily assemble up to four Hi-Duty fittings in the time it takes to assemble one flare fitting. Hi-Duty assembles one-third faster than compression fittings and can be disconnected and reconnected repeatedly without leakage. And they withstand five times as much vibration as compression or flare fittings.

Write for Bulletin No. 3002



Disassembled Hi-Duty Fitting shows how sleeve has become permanently attached to tube.

HOW HI-DUTY SAVES 36% TO 72% ON INSTALLATION TIME!

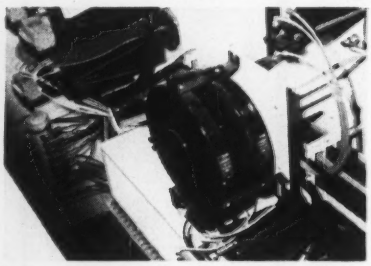
TYPE OF FITTING	AVERAGE TIME FOR EACH JOINT	JOINTS PER HOUR
HI-DUTY	11.7 sec.	307
Regular compression	18.5 sec.	194
Flare	48.2 sec.	74

These studies were made under actual shop conditions.

IMPERIAL

THE IMPERIAL BRASS MFG. CO.
6300 W. Howard St., Chicago 48, Illinois
In Canada: 18 Hook Ave., Toronto, Ontario

Poly-Flo fittings on color-coded tubing simplify servicing



International Paper Company service engineers enjoy simplified checking of 14-foot graphic control panels containing automatic and manual controls for operation of a complete pulp bleaching plant.

Polyethylene instrument loops are color-coded according to products. Nine tubing colors are available conforming to I.S.A. standards. Tube connections are made with Imperial Poly-Flo fittings.

In the event servicing is necessary, the engineer speedily disconnects and reconnects Poly-Flo fittings. No wrench needed . . . fittings need only to be finger tightened and joints stay tight.

Write for Bulletin No. 3025

Free handbook tells how to work with tubing

This practical book tells you how to cut, flare, bend, swage, ream and solder tubing . . . fully describes modern tube-working practice.

Handbook No. 369

CONTACT YOUR INDUSTRIAL DISTRIBUTOR OR WRITE TO:

IMPERIAL BRASS MFG. CO.
Dept. IA-29, 6300 W. Howard St., Chicago 48, Illinois

Please rush me:
Bulletins ☐ No. 3002 ☐ No. 3025 ☐ No. 369

Name .....
Title .....
Company .....
Street .....
City ..... Zone..... State.....

For more information circle **17** on inquiry card.

Ultrasonics industry volume in 1957 exceeded $25 million, reports D. Saslaw of Amperex. Volume of induction and dielectric heating market exceeded $300 million in 1957 (compared to $185 million in 1954).

BDSA (Dep't of Commerce) predicts that key elements in anticipated 1959 improvement are automobile production (now estimated at 5.5 million after the 1958 low), a record construction estimate (mainly housing and roads) of $52.3 billion, and steel output figured at between 105 and 110 million tons (compared with 85 million tons in 1958). Other BDSA predictions:

ELECTRICAL EQUIPMENT: A general strengthening of the electrical equipment market after a disappointing start in 1958 promises a 10% increase in sales in 1959 for a total of $6.5 billion. The industry covers transmission and distribution equipment, motors and control apparatus, lighting equipment, and electrical construction materials.

ELECTRONICS: Spurred by military and industrial needs, total electronics output in 1959 is estimated at $7.9 billion, a new record that exceeds 1958 levels by 14%. More than half goes to the military.

GENERAL INDUSTRIAL EQUIPMENT AND COMPONENTS: After a decline during 1958 from the peak reached in 1957, business outlays for new plant and equipment have firmed toward the close of the year at a $30 billion annual rate.

POWER EQUIPMENT: A slight falling-off is in prospect for steam boiler output after 1958 shipments that ran about 38% over the 10-year average but fell below 1957—a record year.

CHEMICALS: The chemical industry, now spending around $1 billion annually for plant expansion, is charting manufacturers' sales of $24.4 billion in 1959, a 5% increase over 1958 sales of $23.2 billion.

SCIENTIFIC AND INDUSTRIAL INSTRUMENTS AND APPARATUS: Sales in this area in 1959 are expected to rise 10% to 15% above the previous year's estimate of $3.25 billion, because of R&D plus military spending in the guided missile field. Sales in 1958 approximated the 1957 level.

> Common market of Europe, representing a market almost the size of the United States, is causing instrument manufacturers to set up foreign branches. (R. Rimbach, publisher of Instruments & Automation, urged American instrument manufacturers to do this five years ago, upon return from European survey.)

Sales of lab apparatus, instruments and supplies in 1959 will exceed $315 million, predicts J. O. Bengston of Chicago Apparatus Company, compared to about $300 million in 1958, and $295 million in 1957. Increase will be due mainly to increased buying of scientific instruments by industrial concerns, says Bengston, who also reports that in 10 years, laboratory equipment sales increased 95% (lab apparatus by 75%, but laboratory instrument sales by 400%).

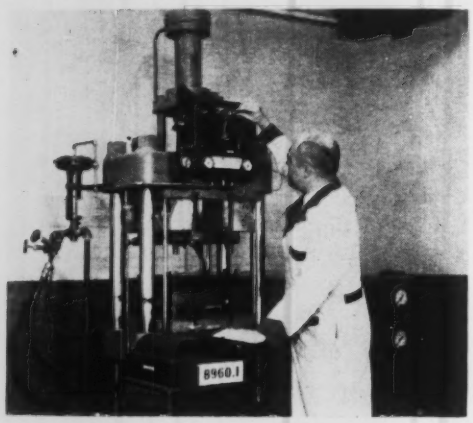
news

NSF Information Service

WASHINGTON, D. C.—Acting upon the recommendations of his Science Advisory Committee, the President has directed that the National Science Foundation take the leadership in bringing about effective coordination of the various scientific information activities within the Federal Government. The President asked that all Federal agencies whose programs involve scientific information cooperate with and assist the National Science Foundation in improving the Government's own efforts in this area.

Mold Temperature Control

CHICAGO, ILL.—Mold temperature control in 100 ton and 50 ton compression transfer presses has been given an unusual twist in the plastic molding department of Bell & Howell Company, Chicago, manufacturers of photographic, optical, and electronic equipment.



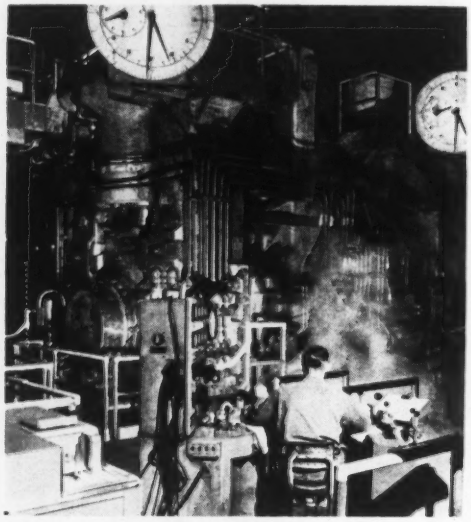
Ignoring textbook warnings, the firm measures mold temperatures by placing the thermal bulb on the outside of the mold half, instead of in the inside or in the steam return line. Control is maintained within plus or minus 3°F. of the required temperature simply by using a Powers Regulator temperature-sensitive Series 100 indicating controller with the thermometer bulb on the outside of the mold half. A surface Pyrometer is initially used to measure the actual mold temperature.

Publisher to Address SCMA

PITTSBURGH, PA.—Richard Rimbach, publisher of *INSTRUMENTS and AUTOMATION*, has been invited by the Southern California Meter Association to give the keynote address when the Eighth Annual Instrument Short Course opens Thursday, March 26, 1959. The two-day course is held annually at Los Angeles Harbor Junior College, Wilmington, Calif., and is sponsored by SCMA in conjunction with the college. Program chairman for the Short Course is Martin E. Kantor, vice-president of SCMA. Details on page 249.

Cards Program Controls for Aluminum Rolling Mill

DAVENPORT, IOWA.—An automatic system at this ALCOA plant follows instructions punched on IBM cards



to establish mill speed and roll opening for a 160-inch reversing mill (widest in the industry), and roll 16"-thick billets into slabs. The system uses a transistorized Westinghouse Prodac system.

Britain's AEA Buys Analog Computer

LONG BRANCH, N. J.—Sale of a Model 231R "Pace" analog computer represents the third such system sold in the United Kingdom to the U. K. Atomic Energy Authority by Electronic Associates' European Sales Office in Brussels. The other two have been sold to the Harwell Research Center and to the General Electric Company at Erith, England. It also represents the 23rd sale of "Pace" Analog Computing Systems to Western European Countries by the European Regional Office since it was opened in July, 1957.

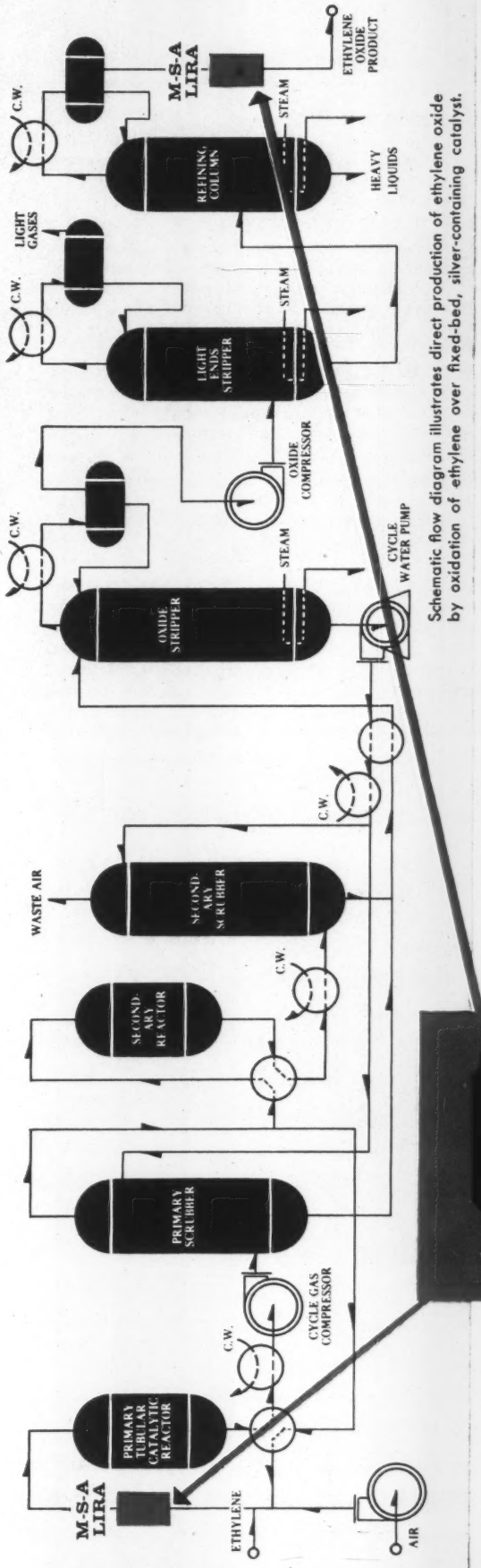
Charles S. Redding

Charles S. Redding, chairman of the Board of Directors and former president of Leeds & Northrup Company died January 2 after a brief illness. He was 75.

Mr. Redding had spent practically his entire business career with L&N. Born in Philadelphia, he joined the then Morris E. Leeds Company as a draftsman in 1901.

Redding soon entered the University of Pennsylvania, graduating in 1906 with a B.S. in electrical engineering. After teaching for two years he rejoined L&N in 1909 as a salesman, but rose to president of L&N from 1939 to 1953, when he became Chairman.

From 1941 to 1946, he was also president of the Franklin Institute. From 1949 through 1951, he was president of the Scientific Apparatus Makers of America. Last year he received the SAMA award for "highest achievement in developing the industry's capacity for serving the nation in the fields of industry, research, education, health and defense."



Schematic flow diagram illustrates direct production of ethylene oxide by oxidation of ethylene over fixed-bed, silver-containing catalyst.

ANOTHER PROBLEM-SOLVING APPLICATION OF M-S-A® LIRA ANALYZERS:

helping to keep reactors operating at peak efficiency in ethylene oxide plants

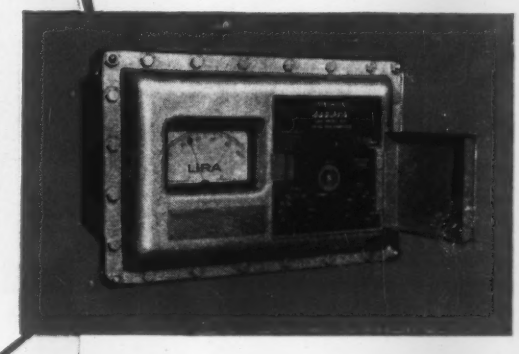
Catalytically oxidizing ethylene to ethylene oxide? You can do it safer, at a greater rate, at less cost by measuring both ethylene input and ethylene oxide product with M-S-A LIRA Model 200 Infra-Red Analyzers

M-S-A LIRA Analyzers can save more than they cost in a matter of months. And they can contribute mightily toward bringing the plant to peak efficiency.

A striking example of this interesting claim is the use of Model 200 LIRA Analyzers in processing ethylene oxide by direct oxidation of ethylene. In this process, LIRAs are used to measure the ethylene in relation to the oxygen input into the reactor. This in turn assures peak operating efficiency of the reactor.

The Model 200 is also used in this process to measure the purity of ethylene oxide being produced as the final product. No need for manual tests for product quality. It's automatic. Continuous. And that's where some of the biggest savings lie. Let's face it: manpower used in process monitoring is expensive. So, let the LIRA do it.

An M-S-A Instrument Specialist will be happy to put our ingenuity to work on your process stream problems: safety, product quality, measurement or control. Consult him. Or write us for helpful literature.



Explosion-proof Model 200 has a tamper-proof lock. All self-checking circuit controls are easily accessible through the explosion-proof enclosure.

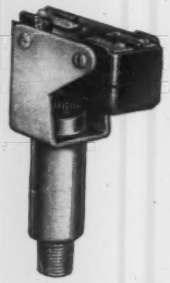
INSTRUMENT DIVISION

Mine Safety Appliances Company
Pittsburgh 8, Pennsylvania

For more information circle **18** on inquiry card.

UNITED ELECTRIC
Multi-Purpose
PRESSURE CONTROLS J7 | J40

▶ Enclosed-TYPE J7



▶ Skeleton-TYPE J40

These controls are compact, precision-built, rugged and inexpensive. Type J7 is ideal for controlling air, gas or liquid pressures up to 500 psi . . . Type J40 for pressures up to 250 psi.

Adjustable Pressure Ranges	J7 . . . various models cover ranges between limits of 0 and 500 psi J40 . . . various models cover ranges between limits of 0 and 250 psi
Switch Ratings	15 amps or 20 amps at 115 or 230 volts A.C., also D.C. switches upon specification
Switch Types	N.C., N.O., or Double throw, no neutral position
Electrical Connections	J7 . . . screw type terminals on switch standard J40 . . . solder type terminals on switch standard
On-Off Switch Differential	Fixed and uniform throughout specified range is standard
Mounting	J7 . . . ¼" NPT female, brass fitting standard J40 . . . ⅛" NPT male, brass fitting standard
Variations	Design variations are available upon specification
Applications	On industrial equipment and engine applications . . . marine, aircraft or special purpose

Although **UNITED ELECTRIC** *offers a complete line of temperature, pressure and vacuum controls . . . UE application engineers specialize in solving unique problems.*

Send for full particulars today. Bulletins available upon request. Type J7 . . . Bulletin No. 5-7, Type J40 . . . Bulletin No. 5-9

United Electric Controls COMPANY
91 SCHOOL STREET, WATERTOWN, MASS

For more information circle **19** on inquiry card.

NEWS—CONTINUED

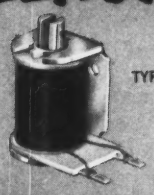
ROYAL McBEE CORP. has installed an LGP-30 electronic computer in the department of biophysics at Johns Hopkins University. It will be used for basic research under a grant from the National Institutes of Health.

NATIONAL CASH REGISTER CO. has installed a $1,000,000 electronic system at Macy's in New York that will prepare customers' statements at the rate of 50 a minute. The installation will include an all-transistor NCR 304 computer and 40 other machines to handle 750,000 customer accounts.

NATIONAL BUREAU OF STANDARDS has developed a simple, compact magnetometer having significant advantages over previous instruments of this kind. The instrument measures extremely small magnetic fields with great accuracy by locating very narrow Zeeman absorption lines in rubidium vapor. Measurements of the earth's magnetic field made in this way differ by about $(6)(10^{-5})$ gauss from the value in terms of the international magnetic standard.

CALIFORNIA INSTITUTE OF TECHNOLOGY Cooperative Wind Tunnel in Pasadena, has installed an analog-to-digital converter system that feeds an IBM Card Punch. The system utilizes 17 L&N Speedomax G, Model D indicators and 17 Datex Model C-901 Shaft Position Encoders. The output of the encoders is converted into decimal form by means of a relay matrix. There are two outputs from each matrix, one output suitable for operating an IBM card punch, and the second suitable for operating a light bank.

NEW SOLENOID



TYPE SL-4

LOW COST
SMALL SIZE
EFFICIENT
POWERFUL

● New, economical, compact design. Extremely efficient, dependable in performance. Available for either AC or DC operation, intermittent or continuous duty. 3 to 220 volts. Normally supplied with flat plunger, but also available with conical plunger for DC only. Send for complete details.

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3349 ADDISON ST., CHICAGO 18, ILL.
RELAYS • SOLENOIDS • COILS • SWITCHES • HERMETIC SEALING

For more information circle **20** on inquiry card.

for your personal or company library

DIGITAL TECHNIQUES FOR COMPUTATION AND CONTROL

by Martin L. Klein, Harry C. Morgan, Milton H. Aronson . . . FIRST comprehensive survey of basic digital techniques . . . includes basic principles, basic circuits, components and available commercial equipments . . . Dynamic digital material thoroughly covered in 394 pages. Cloth bound with dust jacket, illustrated. 5½" x 8½" **$6.00**

AUTOMATIC CONTROL TECHNOLOGY, MODERN THEORY AND THEIR USEFULNESS

edited by Gerd Mueller, for VDI/VDE-Fachgruppe Regelungstechnik. Includes 90 advanced papers on control technology, as delivered in original language (English, French, German, Russian: all Russian papers are translated into German: about ½ of book is in English). 9" x 12". Handsome cloth binding. Printed by R. Oldenburg Verlag, Munich, Germany. 483 + XV pages, 1957, 898 illustrations and 48 tables **$25.00**

PRINTED CIRCUITRY

by Allan Lytel. A valuable working tool; includes alternative and recommended practice for each step in design and production of printed circuits; a buyer's guide to special components; and "how to" service data. Paperbound, illustrated, 192 pages, 1957 ..... **$2.00**

CONTROL VALVES

by C. S. Beard. New "one-book" reference on control valves . . . covers flow characteristics; mechanical features; valve capacity; sizing; body types; positioners; actuators, including d-c, electrohydraulic and gas hydraulic actuators. Numerous tables and illustrations. Paperbound, 236 pages, 1957 ..... **$2.00**

MAINTENANCE AND SERVICING OF ELECTRICAL INSTRUMENTS

by James Spencer. Useful to all instrument users, service men, switchboard attendants testing engineers, and others, this book covers construction, testing, applications, principles of operation and maintenance of all kinds of electrical indicating instruments. Clothbound. 274 illustrations, 280 pages. 1951 (third edition) ..**$2.00**

100 ELECTRONIC CIRCUITS

by M. H. Aronson and C. F. Kezer . . . covers amplifiers, oscillators, pulse circuits, phototube circuits, phase shifters, etc. Complete with all circuit component values and response specifications. paper, 180 pages, illustrated **$2.00**

ELECTRONIC CIRCUITRY FOR INSTRUMENTS AND EQUIPMENT

by Milton H. Aronson . . . a complete home-study text and course, with 458 multiple-choice home-study test items on basic electronic circuitry for instruments, communications, TV, laboratory apparatus, and military equipment. First edition was a complete sell-out. Third edition revised and up-to-dated. paper, 312 pages illustrated **$2.00**

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by Millard H. LaJoy and E. Allen Baillif . . . an essential first step in analysis of closed-loop controlled process via frequency response of the system. 1956. cloth, 72 pages, illustrated **$2.00**

STRAIN GAGE INSTRUMENTATION

edited by Milton Aronson and Robert C. Nelson ". . . a practical text . . . covers fundamentals, basic bridge circuits, typical applications, and surveys typical commercial instruments which use or are used with strain gages." 104 pages plus vi, 1958, illustrated, company index, author index, subject index **$2.00**

PROCESS CONTROL

by A. J. Young, Head of the Central Instrument Laboratory, Imperial Chemical Industries, Ltd. ". . . a MUST for all men who have to do with the automatic control of industrial processes; combines the practical "how" and the theoretical "why." 1955. cloth. 134 pages. illustrated **$2.00**

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by June, Bardis, Lurio, Polaner, Sagedahl, Sklenar and Yenken. Here is THE book for all who want FACTS rather than wild opinions . . . a fresh viewpoint on what "manless factories" CAN be—a book free from the generalities, platitudes, exaggerations, and misconceptions repeated by many writers on this subject. 1955. cloth, 88 pages, illustrated **$1.50**

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Here's why they give you economical, long-life performance:

- **Simple operation.** The Edison Resistance Temperature Detectors consist essentially of a piece of high-resistance wire. When variations in the temperature of the measured medium cause a change in the resistance of the wire, enough power is developed to operate an indicator or relay and no amplification is required.
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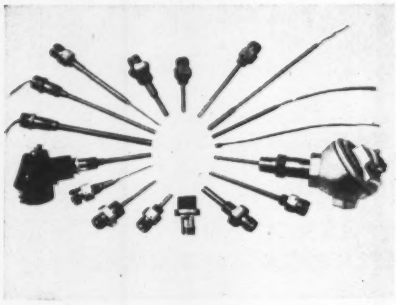

Edison Detectors are available for a wide range of applications and almost any type of service. They are compact, corrosion and vibration resistant.

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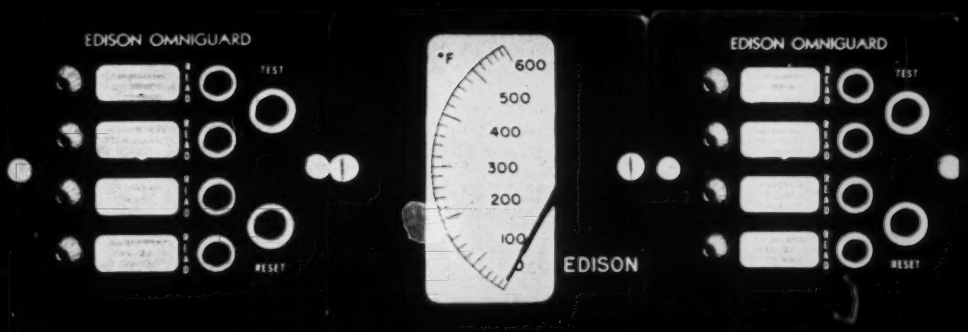
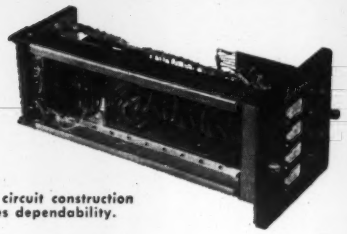
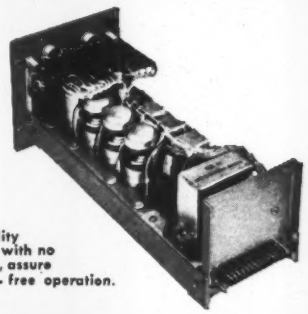
For more information circle **22** on inquiry card.

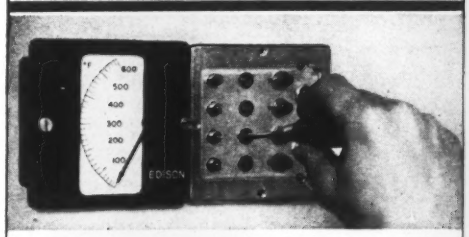




Printed circuit construction increases dependability.



Highest quality components, with no moving parts, assure maintenance-free operation.



Easy access to all components permits quick temperature settings and monitoring system changes – at any time.

Model 310 Edison Omniguard with Model 311 Indicator — a single indicator can read any number of temperature points.

THOMAS A.

EDISON

new model 310 omniguard temperature monitor... unmatched for versatility

The new Model 310 Edison Omniguard provides the simplest, most dependable temperature detection system yet devised... for both small and large installations.

The Omniguard system is reliable... flexible... economical. You order only the plug-in units needed, add new units as your monitoring needs expand.

Check these features of the new Edison Omniguard:

1. VERSATILE: One instrument can be used for both normally open and normally closed annunciator... for alarm or for shutdown of equipment.

2. FLEXIBLE: Quick, inexpensive system changes and additions . . . easy tie-in with any type annunciators or cut-off switches.

3. DEPENDABLE: Rugged design with highest quality components, no fragile moving parts.

4. SIMPLE: Single indicator reads any number of temperatures, needs no periodic adjustment. With a minute's briefing, *anyone* can operate the simple Omniguard monitoring system.

5. LOW COST: Plug-in units can be custom-tailored to your exact requirements . . . order additional units only when needed.

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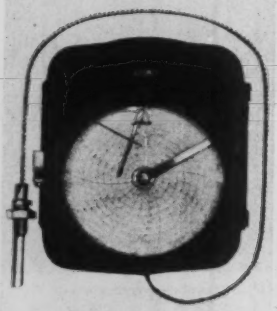
For more information circle **23** on inquiry card.

FIG. D-32
MULTI-ANGLE
ADJUSTABLE
DIAL THERMOMETER

Accuracy at every degree... that is what's built into MOELLER Dial Indicating and Recording Thermometers



RECTANGULAR CASE
RECORDING
THERMOMETER
with Separable
Socket Connection

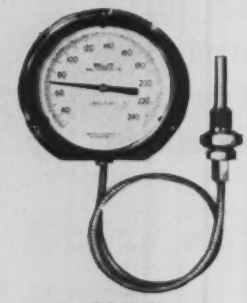


FIG. D-20
REMOTE
READING TYPE
DIAL THERMOMETER
with Separable
Socket Connection

Dependability has been the trademark of Moeller Instrument Co. for 91 years. Over that time it has been our pride to engineer and manufacture temperature indicating instruments of the highest quality and finest precision. Moeller Dial Indicating and Recording Thermometers have been specially designed for temperature sensitivity and for ruggedness under adverse installation conditions. Uniform scale divisions permit easy, accurate readings. Scale ranges from −40° F. to +1000° F. (or centigrade equivalent).

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Gentlemen: Without obligation, please send me Moeller Catalog No. 150 on Dials Indicating and Recording Thermometers.

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stock report

Any further information concerning any of the following issues may be obtained from the Research Department, Bache & Co., 36 Wall Street, New York 5, N. Y.

American Stock Exchange:

PRICE RANGE 1958-59 THROUGH January 13, 1959

	HIGH	LOW	PRICE AS OF 1/13/59
American Meter	39 1/2	27 5/8	39½-39 3/4(1
Arc Equipment	23 1/2	13 3/4	22 1/2
Barry Controls "B"	17	4 3/8	15 3/4
Baseak Instruments	13	7 3/8	11 3/8
Bourns Watch	7 1/2	4 7/8	6 1/4
Breeze Corp.	7 1/8	5 1/8	6 1/2
Clark Controller	24	14 7/8	20 3/4
Clarostat Mfg.	5 1/2	2 7/8	4 3/8
Clary Corp.	7	2⅞	6 1/8
DuMont Laboratories	8 1/4	3	6 7/8
Dynamics Corp. of America	5 1/2	2 7/8	4 7/8
Electronics Corp. of America	16 1/4	6 3/8	12 7/8
El-Tronics	3 3/4	5/8	1 1/8
Fairchild Camera & Instrument	64 3/4	19 1/2	59
Globe-Union	22 7/8	14 5/8	20 1/2
Haseltine Corp.	62 3/8	30 1/2	60 3/4
International Resistance	9 1/2	3 3/4	7
Lear, Inc.	10 1/4	4 1/4	9 1/4
National Research	25	12 7/8	24 3/4
Neptune Meter	35 1/4	19 1/2	34 1/2
New Haven Clock	3 1/4	7/8	2 1/4
Nuclear Corp. of America	3	7/8	3
Pneumatic Scale	40	18 1/2	39 1/2
Servo Corp. of America	21	3 3/4	17 3/4
Servomechanisms	11 3/4	6 5/8	9 1/2
Wallace & Tiernan	40 3/4	24	39
Waltham Prec. Instrument Co.	1 3/4	13/16	1 5/8

1) Not Traded - Bid and Asked

New York Stock Exchange:

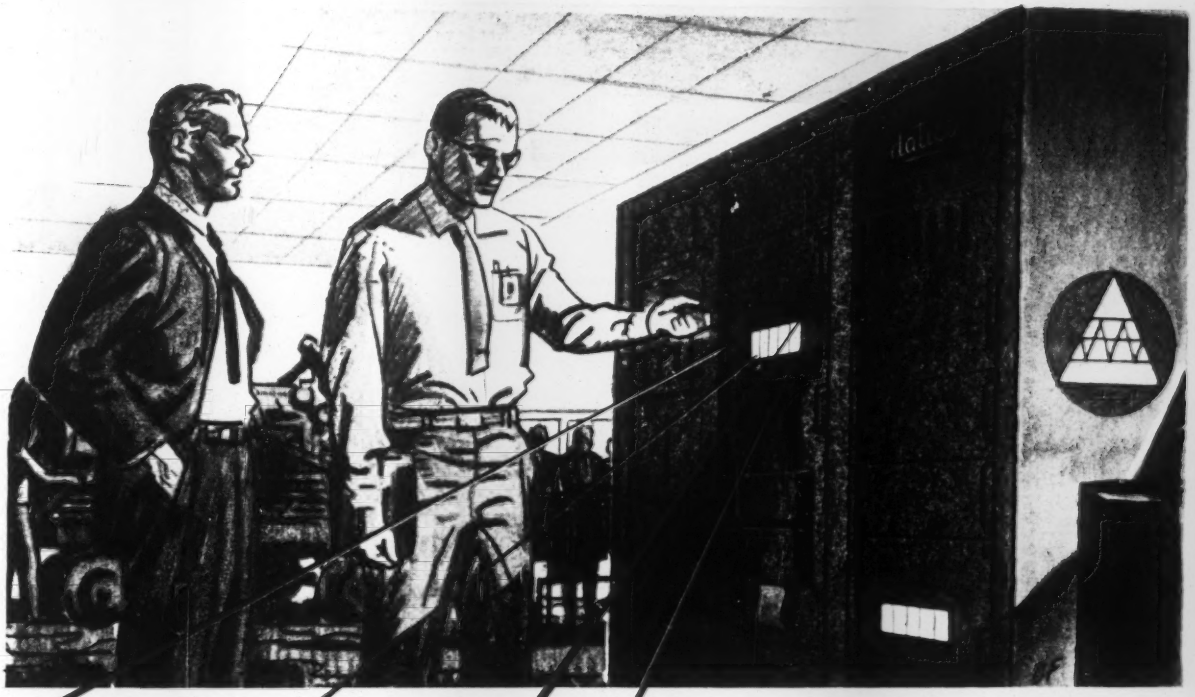
Price Range for 1958-59 through January 13, 1959

	HIGH	LOW	PRICE AS OF 1/13/59
ACF Industries	52 7/8	37 1/8	52
Aeroquip Corp.	28 1/4	16 7/8	26 5/8
Allis Chalmers	30 1/8	22 1/8	29 3/8
American Chain & Cable	52	39 1/2	51 3/4
American Machine & Foundry	59 3/4	32 1/4	57 3/8
American Machine & Metals	84	47 1/2	77
American Optical	42 3/4	34 3/4	41 3/4
American Tel. & Tel.	240 1/2	167 7/8	235 1/8
Beckman Instruments	41 3/8	18 1/8	40 3/8
Bell & Howell	94 7/8	42	82
Bendix Aviation	74 1/2	44 1/2	68 3/4
Boeing Airplane	58 1/8	34 1/8	43 3/4
Bullard	18 1/2	10	17 3/4
Bulova Watch	16 3/4	9 3/4	14 5/8
Burroughs	43 3/8	27 5/8	38 1/4
Carborundum	41 3/4	30 7/8	38 3/4
Cincinnati Milling Machine	44 1/2	27	38 3/4
Clevite	30 1/2	15 3/4	29 7/8
Columbia Broadcasting System	41 1/2	24 1/8	35 5/8
Consolidated Electrodynamics	47 1/2	27 7/8	38 1/4
Consolidated Electronics	44 3/4	19 1/2	38 3/8
Cornell Dubilier	24 7/8	12 3/4	21 7/8
Corning Glass	102 1/2	74 5/8	99
Curtiss-Wright	31 1/2	20 5/8	28 5/8
Cutler-Hammer	63 3/4	40 1/2	63 1/2
Daystrom	39 3/4	30	37 1/8
Douglas Aircraft	74 7/8	54 1/2	57 1/4
Eastman Kodak	154	97 1/8	146 3/4
Eaton Manufacturing	59	38 1/2	56 1/2
Electric Auto Lite	39	25	37 1/4
Elgin Watch	11 3/8	6 3/4	10 3/4
Emerson Electric	56 1/2	29	49
Food Machinery & Chemical	46 1/4	35 1/4	44 5/8
Gamewell	36 1/2	20 1/2	34 1/4
Garrett	44 1/2	27	41 1/4
General Controls	28 3/8	14	26 1/4
General Dynamics	67 3/8	55	62
General Electric	80 1/4	57	78 7/8
General Instrument	22 3/8	4 5/8	19 1/8
General Mills	94	60 1/4	93 1/8
General Precision Equipment	41	27	33 1/2
General Railway Signal	38 7/8	21 1/8	37
General Telephone	63	40 3/8	62
General Time	49	16 5/8	43
General Tire & Rubber	50 1/4	22 1/4	45 1/4
International Business Machine	552	300	524 1/8
International Tel. & Tel.	65 3/8	29 1/4	62 7/8
ITE Circuit Breaker	42 3/8	34 3/4	38
Litton Industries	90 3/4	36 7/8	77 1/4
Lockheed Aircraft	69 1/8	38 3/8	63 1/8
Magnavox	60 1/2	30 1/4	53
Mallory	39 7/8	23 5/8	39 3/8
Minneapolis-Honeywell	126	76	119 3/4
Minneapolis Mining & Mfg.	121 1/2	73 1/2	120 3/4

Continued on page 188

FOR MORE INFORMATION ON ANY OF THE PRODUCTS REPORTED OR ADVERTISED IN THIS ISSUE, CIRCLE THE ITEM NUMBER ON THE INQUIRY CARD ON PAGE 291. IF THE CARD HAS ALREADY BEEN USED, WRITE NUMBER; DATE OF ISSUE; YOUR NAME, ADDRESS, COMPANY, PRODUCTS MANUFACTURED ON A POSTAL CARD. MAIL C/O READER SERVICE.

Transistorized NLS M-24 Selected for Missile Checkout System



Analog to digital conversion in Nortronics' Universal Datico is accomplished by the ultra-reliable NLS M-24, the transistorized Digital Volt-Ohmmeter that automatically and accurately measures and displays AC and DC voltages, voltage ratio and resistance.

In Datico, program control is performed by a punched paper tape. Test stimuli are automatically controlled by Datico and output signals (voltage, voltage ratio, and resistance) from the system under test are automatically selected and fed to the NLS M-24. The M-24 digitizes the system outputs to 0.01%, and provides numerical data to the indicator and control chassis for distribution to the data recorder, digital comparator, and visual display on a special NLS in-line readout.

The tape also establishes the go-no-go limits for comparison with the M-24's digital output. It then directs the system to the next channel to be measured.

Operation of the NLS M-24 in this system is completely automatic . . . the instrument is remotely operable, does not require zero setting, and is extremely stable over very long time periods. Over-all system speed is not compromised by analog to digital conversion time, the M-24 making each measurement in just 330 milliseconds.

The NLS M-24 meets the unusually great reliability demanded of automatic test equipment for modern electronic weapons systems. This reliability is assured by transistors, mercury-wetted contact relays (rated at 10 billion measuremenrs), advanced circuit design, and thorough production and field testing.

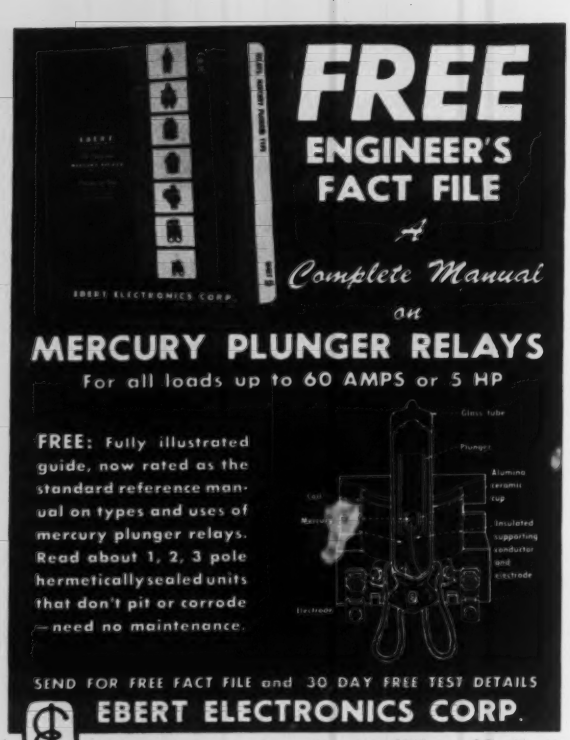
Proved in the field in a variety of applications, the NLS M-24 Digital Volt-Ohmmeter is in production and ready to go to work for you. Write today for detailed information concerning this outstanding example of NLS leadership in the development and manufacture of digital instruments. A complete catalog of NLS instruments will be sent upon request.

Originators of the Digital Voltmeter

non-linear systems, inc. DEL MAR (San Diego), CALIFORNIA

NLS—The Digital Voltmeter That Works...And Works...And Works!

For more information circle **25** on inquiry card.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100% AUTOMATIC TANK GAUGING

Dependable remote reading tank contents gauges using a closed hydraulic transmission system. No power required.

Several sizes available. Approved by Underwriters Laboratories and Factory Mutual. UL approved switches.

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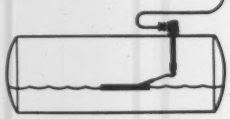

Since 1920 of proven quality

THE LIQUIDOMETER CORP.
LONG ISLAND CITY 1, NEW YORK

For more information circle **27** on inquiry card.

New York Stock Exchange: *Continued from page 186*

Motorola	60 1/2	35	58 3/4
National Acme	59 1/4	43 7/8	52 1/2
National Cash Register	86 1/4	50 1/2	75 3/8
North American Aviation	45 7/8	25 5/8	43 1/2
Northrop Aircraft	37 1/2	22 1/8	34 1/2
Otis Elevator	75 1/4	40 1/4	67 1/2
Philco Corp.	26 3/8	12 3/8	22 7/8
Radio Corp. of America	48 1/4	30 1/4	48
Raytheon Mfg.	69	21 1/2	61 3/4
Reliance Electric	50 1/4	31	43
Rheem Mfg.	20 1/2	10 1/2	19 1/2
Robertshaw-Fulton	35 1/4	22 1/4	33
Royal McBee	25 1/4	16	23 1/4
Sangamo Electric	45 1/2	25	44 1/8
Sperry Rand	25 3/8	17 1/4	23 7/8
Square D	31 1/2	20 1/8	29 7/8
standard Coil Products	17 5/8	6	17 5/8
Starrett (L.S.)	74 3/4	57	66
Stevart-Warner	45 1/4	29	43 1/2
Sylvania Electric	61 1/2	31 1/2	60 1/2
Telautograph	10 7/8	3 3/4	10 1/4
Texas Instruments	86	26 3/4	71 1/8
Thompson Ramo-Wooldridge	73	41 3/8	66 5/8
Tung-Sol Electric	39 1/8	23 1/4	38 3/4
Underwood Corp.	23 1/8	12 7/8	21 3/8
Union Carbide Corp.	127 1/4	83 7/8	125
United Shoe Machinery	47 3/4	32	46 1/2
Western Union	34 3/4	15	31 7/8
Westinghouse Air Brake	34 3/8	17 7/8	33 3/4
Westinghouse Electric	74 1/2	55 1/2	74
Worthington Corp.	74 1/4	45 1/4	73

Over-The-Counter

QUOTATIONS AS OF JANUARY 13, 1959

	BID	ASKED
Aerovox Corp.	6 1/2	7
Aircraft Radio Corp.	29 3/4	31
Argus Corp.	33 3/4	34 1/2
Fitel-McCullough	26	27
Electronics Associates	53 1/2	57
Erie Resistor Corp.	8 3/4	9 1/2
Fisher Governor Company	17 3/4	18 1/2
FoxboroCompany	49 1/2	52
G.M.Giannini	26 1/2	30 1/2
Industro Transistor	3	3 5/8
Liquidometer Corp.	7 3/4	8 1/4
W. L. Maxson	13 3/4	15
Penn Controls, Inc.	19 1/4	20 3/4
Speer Carbon, Inc.	30 1/2	31 3/4
Sprague Electric	41 1/2	43
Taylor Instruments	34 1/4	35 3/4
Telecomputing Corp.	8 1/2	9
Topp Industries	13 1/8	13 5/8
Varian Associates	50	53
Vitro Corp. of America	15 1/2	16

OPTICS

A. D. JONES OPTICAL WORKS

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CAMBRIDGE 40 MASSACHUSETTS
TRowbridge 6-3368—3369

A LIST OF MATERIALS WE FABRICATE USED IN OPTICS AND ELECTRONICS

SAWING GRINDING POLISHING DRILLING

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BARIUM TITANATE
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BRASS
CARBORUNDUM
CERAMIC
COBOLT FERRITE
COPPER
*CORNING 707
*CORNING 7052
CUPROUS BROMIDE
FERRITE
FERROX
**FLUORIDE, CALCIUM
**FLUORIDE, LITHIUM
GALLIUM ANTIMONIDE
GALLIUM ARSENIDE
GARNET
GERMANIUM
GOLD
INDIUM ANTIMONITE
INDIUM PHOSPHIDE
INDOX
IRON SINGLE CRYSTAL
LITHIUM FERRITE
MAGNETIC PLUMBITE
MELAMINE FIBER GLASS
MICA, SYNTHETIC
NICKEL OXIDE
PLATINUM
POTASSIUM BROMIDE
*PYREX
*QUARTZ, CRYSTAL
*QUARTZ, FUSED
**SAPPHIRE
**SODIUM CHLORIDE
**STEEL
STRONTIUM TITANATE
TEFLON
TITANIUM DIOXIDE
*VYCOR
*X-RAY LEAD GLASS
ALL TYPES KNOWN GLASS

* Carried in stock
** Purchased for orders

For more information circle **28** on inquiry card.

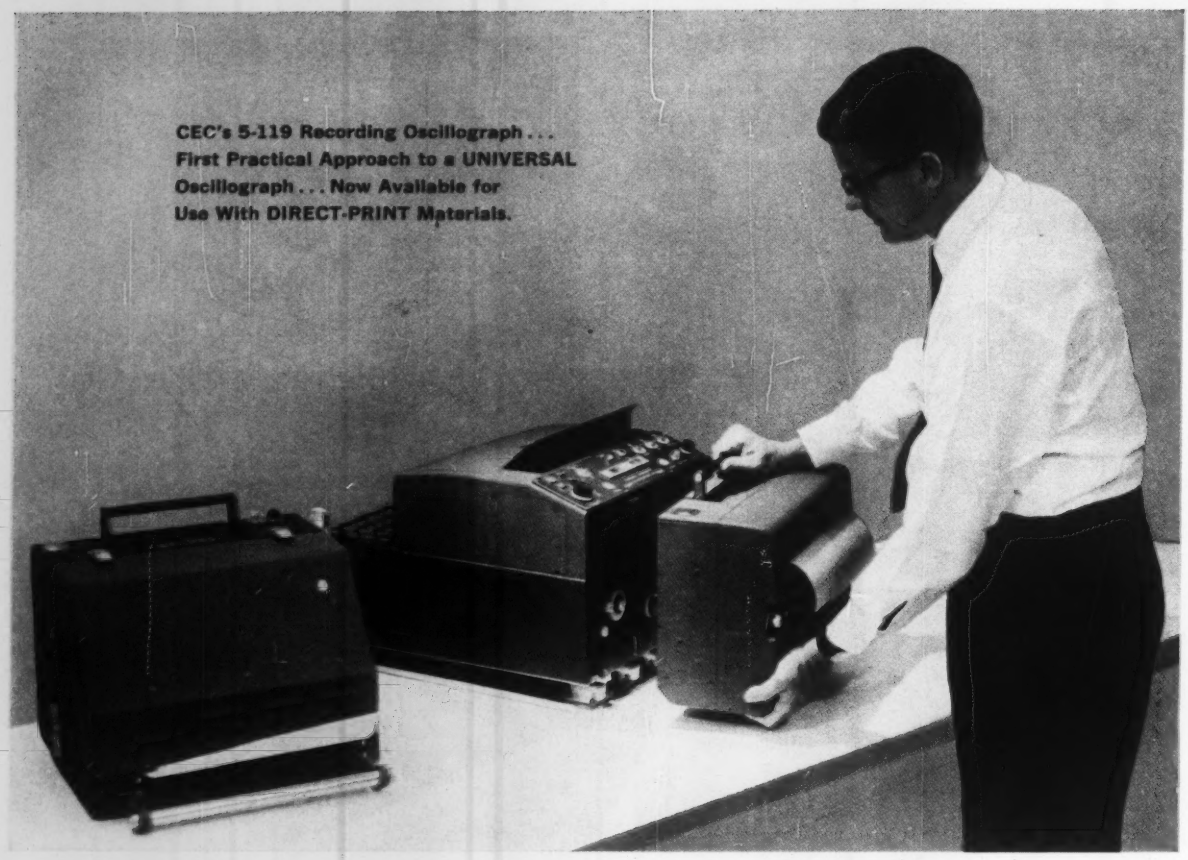
does both jobs equally well – Burroughs 205 Computer

From the sequential solution of long scientific problems to the mass processing of business data, the versatile Burroughs 205 electronic data processing system is ideally suited to a wide range of applications. Top capacity and speed in the medium price class, complete choice of input-output media, vast external magnetic tape storage. At work in many varied industries, the 205 has proven its superior dollar-for-dollar value. Its flexibility lets you grow into a larger Burroughs system as your needs increase. Burroughs extensive support program provides on-the-spot technical assistance for an advanced and complete line of data processing systems…all currently in production. Write for 205 brochure. ElectroData Division, Pasadena, California.

Burroughs Corporation

"NEW DIMENSIONS/in electronics and data processing systems"

For more information circle **29** on inquiry card.


CEC's 5-119 Recording Oscillograph . . .
First Practical Approach to a UNIVERSAL
Oscillograph . . . Now Available for
Use With DIRECT-PRINT Materials.

New recording versatility with 3 interchangeable magazines

With a new high-actinic light source and Slot-Exit Magazine, the 5-119 now becomes one of the most truly universal tools of data processing available. Addition of the direct-print process and new magazine to the 5-119 now brings you three uniquely different recording processes, enabling engineers to select the process best suited to specific test requirements.

PROCESS 1 DIRECT-PRINT... Clearly resolves writing speeds to 100,000 ips. High-actinic light source 5-119 P4-36V (or -50V) and new 5-051 Slot-Exit Magazine produce records on standard direct-print papers without chemical processing of any kind. Records emerge from the magazine slot continuously, and latensification takes place in ordinary room fluorescent light.

PROCESS 2 RAPID-ACCESS... Provides the shortest access time of any known process, and yields records of higher trace contrast and greater permanency than afforded by direct-print materials. Process employs the 5-036B DATARITE Magazine which automatically develops and dries oscillogram as quickly as data are recorded. Provides ready-to-read test results almost simultaneously with the occurrence of events under study.

PROCESS 3 CONVENTIONAL... Used where the finest available recording trace and contrast with highest writing speed are paramount requirements. Records are contained by the 5-006A Standard Magazine which uses conventional 12-inch films or papers. Records are processed following the record run.

The 5-119 provides 36 or 50 independent data input channels... Wide record-speed and frequency-ranges... Flash-Timing System to synchronize timing lines of 2 to 100 remote oscillographs. For complete details call your nearest CEC sales and service office, or write for Bulletin CEC 1536-X3.

Electro Mechanical Instrument Division CEC

CONSOLIDATED ELECTRODYNAMICS *300 No. Sierra Madre Villa, Pasadena, Calif.*

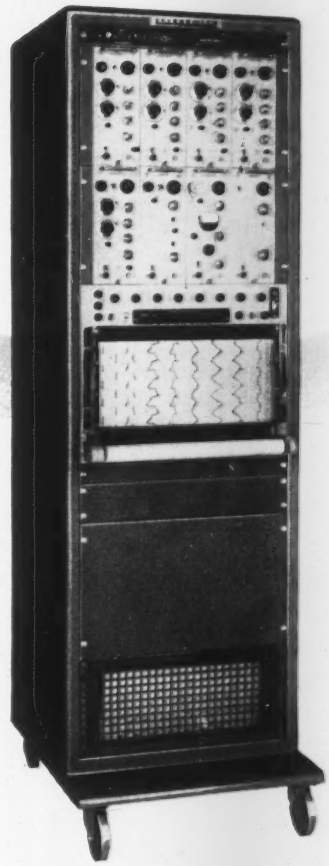
FOR EMPLOYMENT OPPORTUNITIES WITH THIS PROGRESSIVE COMPANY, WRITE DIRECTOR OF PERSONNEL

For more information circle **30** on inquiry card.

- **Flat frequency response** from 0 to 100 cps
- **Galvanometer** natural frequency 55 cps
- **Hysteresis less than ± 0.1 div.**
- **True velocity damping** for galvanometer at all times — limiting ahead of output stage
- **Current feedback power amplifiers** eliminate effect of galvanometer resistance changes due to temperature
- **Linearity 0.2 div.** over entire 50 div. chart width
- **Gain stability** better than 1%
- **Base line drift less than 0.2 div.** over 20°C. changes
- **Automatic stylus heat control**
- **Inkless recording** in true rectangular coordinates

PERFORMANCE

is the best proof of SANBORN "350" System Quality



8-CHANNEL SANBORN "350"
Direct Writing Oscillographic Recording System . . .
also available with 6 channels

Only the Sanborn "350" oscillographic recording system offers *both* superior performance *and* operating versatility. You can interchange the plug-in preamplifiers — or use them separately with their own power supplies to drive a scope, meter, or optical oscillograph. The compact recorder (17½ inches tall), complete with transistorized power amplifiers and power supply, may also be used separately (sensitivity 0.1 volt/chart division). That's real versatility!

Recorder features include built-in paper footage indicator, paper take-up, 8" of visible record, simple paper loading from the front. Nine electrically controlled chart speeds are selected by pushbuttons, and have provision for remote control. Connections are also provided for output monitoring.

All these features — plus well-known Sanborn reliability — are yours in the Sanborn "350" system. Ask your local Sanborn Industrial Sales-Engineering Representative for complete facts — or write the Industrial Division in Waltham.

At the I.R.E. Show — Booths 3601-3605

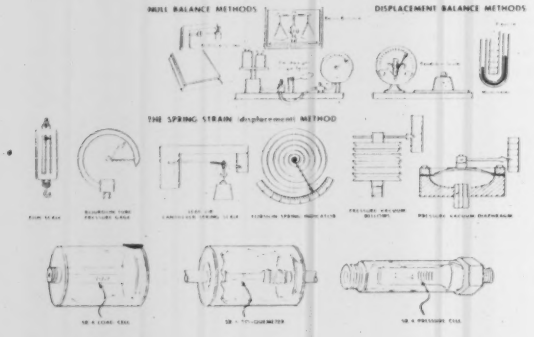
SANBORN COMPANY
175 Wyman Street, Waltham 54, Mass.

For more information circle **31** on inquiry card.

briefs

Force Measurement

Forces are measured by balancing against a calibrated reference in these most common ways . . .

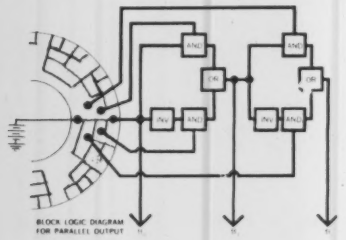


(*From new 20-page booklet "Modern Force Measurement," containing survey of entire force-measuring field, Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div., 42 Fourth Ave., Waltham, Mass.*).

For this literature circle **131** on inquiry card.

Shaft Position-to-Digital Encoders

V-SCAN, a most important feature of Librascope shaft encoders is the positive elimination of readout ambiguity. By definition, an ambiguous readout may arise where more than one binary bit is changing state; e.g., 0111-1000. In the Librascope Shaft Position-To-Digital Encoders, this difficulty is eliminated by the logical positioning of all brushes in the encoder with respect to disc pattern and logical brush selection.

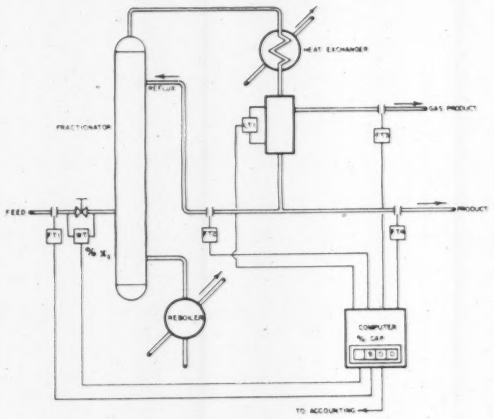


Two brushes are placed on each bit track with the exception of the least significant track, which has only one brush. This least significant brush is the controlling element. The instantaneous state of this brush determines, through simple external logical circuitry, which of the two brushes on the next most significant track will be used. This selected brush then becomes the controlling element for its adjacent pair of brushes, etc. In this manner the logic is propagated from the least to the most significant bit. Therefore the accuracy of any encoder, regardless of capacity, can never be less than one count in the least significant bit. Because of their high scanning rate capabilities, the encoders can be used in serial or parallel applications. They may be readily time shared through the use of isolation diodes in each bit line; however, the diodes are not required unless time sharing is desired . . . (*From new 8-page Brochure "Shaft Position-to-Digital Encoders," Librascope, Inc., 808 Western Ave., Glendale 1, Calif.*)

For this literature circle **132** on inquiry card.

In-Process Computers

SIE's new type CM-2 analog computer in the process loop, provides a degree of control unobtainable with single loop control. First, it allows consideration of as many variables as required, and second, the computer can efficiently control non-linear process by computation of the correction that must be applied to a standard linear controller input . . . Complicated processes involving a material and heat balance and/or exothermic reactions are often characterized by two



$$\text{Performance \%} = 100 \times \frac{(FT_3 + FT_4 + \frac{d(LT_1)}{dt}}{(FT_1)\ (\%X_1)}$$

or more equations. Variables are supplied directly from the process and the computer generates an output signal representing the optimum setting for two or more controlled variables.

Calculation of process performance as a Control-Room Guide for improved operation: The theoretical capacity of this process is proportional to a function of feed flow and composition, which can be used as a basis for a performance calculation. The overhead product is the sum of the three-flow measurements: product, reflux and gas. This sum is used as a numerator in the performance ratio computation shown . . . (*From new 4-page Bulletin CM658, Southwestern Industrial Electronics Co., 2831 S. Post Oak Rd., P. O. Box 13058, Houston 19, Texas*).

For this literature circle **133** on inquiry card.

What's best for **TEMPERATURE MEASUREMENT** *and* **RECORDING?**

In any application—one or more of these stable, sensitive Weston instruments will fill the job best!

BI-METAL

Exceptionally rugged, reliable, sensitive elements. Corrosion-proof, pressure-tested stainless steel stems and connection nuts. Large, easily readable scales. Heavy-duty, industrial and laboratory types. Heads from 2" to 6" in diameter. Standard stem lengths from 2½" to 72". Ranges low as −100F to as high as 1000F . . . or −100C to 400C. Accuracies within 1% of full-scale range. Write for Catalogs 09-100, 09-400.

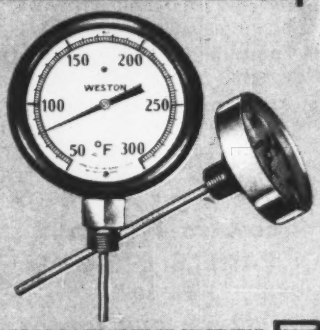
FILLED SYSTEM

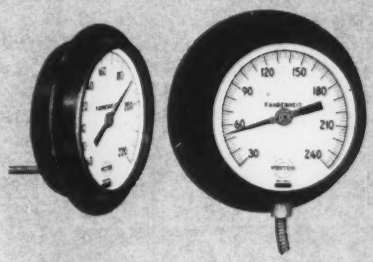
Indicators with mercury, liquid, gas or vapor pressure actuations in 5", 6" and 8" dial sizes—for wall or flush mounting. Ranges as low as −325F to as high as 1000F. Available with adjustable electrical contacts and index pointers for signal or alarm needs. Unitized single- and multi-pen recorders may use all actuations interchangeably. Versatile pneumatic control forms also available. Write for Catalogs 09-200, 08-701, 08-704.

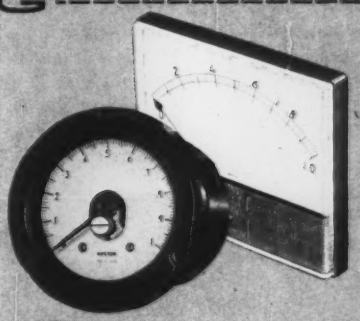
ELECTRICAL

An exceptionally broad line of instruments for remote and multiple readings and recordings. Rugged, long-scale indicators—available with selector switches for readings from several sources. Accuracy within 1% of full scale. Ranges as low as −300F to as high as 5000F. Unitized strip- and circular-chart potentiometer recorders are accurate within ¼% of range. As many as 24 sources can be accommodated by one instrument. Write for Catalogs 01-107, 01-501, 08-202.

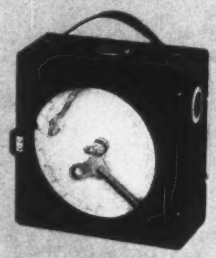
INDICATING

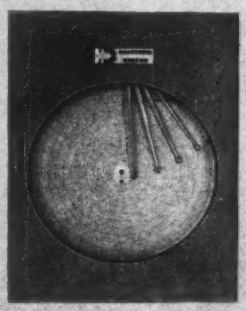


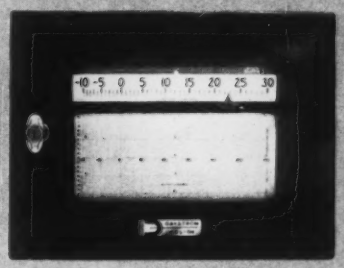




RECORDING







For full information, contact your local Weston representative . . . or write to Weston Instruments, Division of Daystrom, Inc., Newark 12, N. J. *In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 10, Ont. Export: Daystrom, Int'l., 100 Empire St., Newark 12, N. J.*

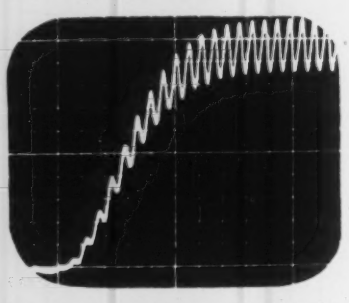
WESTON *Instruments*

A DAYSTROM UNIT

For more information circle **32** on inquiry card.

Oscilloscope Record Cameras

The DuMont 339 Oscilloscope-record Camera provides facilities for recording oscillograms from 3-inch oscilloscopes. Some features usually only available in higher priced units are: f/2.8, 50-mm lens, Alphax shutter, binocular viewing, quick connect/disconnect bezel fixtures and light-weight construction . . .



In designing cameras for 3-inch oscilloscopes, probably the greatest obstacle is the size of the camera and the available space it occupies when attached. The small size requirement demands that the distance between film and object be short, thus forcing the lens designer to provide great lens speed without image distortion . . . The 339 Camera uses all of the standard Polaroid-Land emulsions . . . (*From new 12-page Bulletin "Oscilloscope Record Cameras," Allen B. DuMont Laboratories, Inc., Instrument Div., 760 Bloomfield Ave., Clifton, N. J.*)

For this literature circle **134** on inquiry card.

Chromatography and Distillation Course

Gas chromatography course on analysis of gases and liquids (Two-week session presented in January, March and May):

Factors Influencing the Design of Chromatographic Equipment
Retention Volume Considerations
Partition Coefficients
Column Efficiency Studies
Qualitative Analysis
Quantitative Analysis
Janak Method of Analysis
Guide to colume Selection for Particular Separations
Special Chromatographic Techniques

Distillation course on analysis of gases and liquids (One week session presented only in January):

Analytical Distillation Equipment
Operational Procedures in Analytical Distillation
Calculation of Results
Re-Analysis Techniques

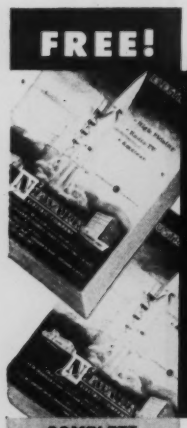
(*From new 8-page "Where" magazine announcing courses for 1959 at Podbielniak Institute and new instruments, Podbielniak, Inc., 341 E. Ohio St., Chicago 11, Ill.*)

For this literature circle **135** on inquiry card.

Ultrasonic Fabrication

Aeroprojects has developed production-type . . . ultrasonic metal-joining equipment, which is being manufactured and sold under the trade names SONOWELD, SONOSOLDER, and SONOBRAZE . . . (*From new 16-page binder, Aeroprojects Incorporated, West Chester, Pa.*)

For this literature circle **136** on inquiry card.



FREE!

NEWARK'S ALL NEW 1959 INDUSTRIAL ELECTRONIC CATALOG NO. 69!

A Big 388 page Reference to the Latest Electronic Equipment Releases!

Complete Listings at Factory Competitive Prices — SEMI-CONDUCTORS • CONNECTORS • RELAYS • SWITCHES • INDUSTRIAL TUBES • TEST EQUIPMENT • TRANSFORMERS • CONTROLS • RESISTORS • METERS • CAPACITORS • PILOT LIGHT ASSEMBLIES

Write for Your Copy Today!

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FULL LINE OF CANNON AND AMPHENOL CONNECTORS In Stock!

Midwest Semi-Conductor Headquarters — all in stock at Quantity Prices Competitive with Manufacturer!

Texas Instrument • Hughes • Hoffman • Philco • General Transistor • General Electric • RCA • CBS-Hytron • International Rectifier • Motorola • Sylvania • Raytheon

Your One-Point Source for All Your Electronic Needs!

NEWARK ELECTRIC COMPANY

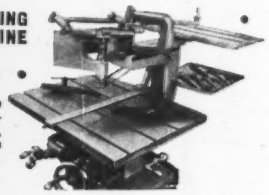
Dept. IN-2 223 West Madison Street, Chicago, Illinois
Dept. IN-2 4747 West Century Blvd., Inglewood, Calif.

For more information circle **33** on inquiry card.

how to ENGRAVE PANELS & SIGNS to 30" wide by any length

Use the **LOW COST** *precision built* **PREIS-PANTO 2D-4**

ENGRAVING MACHINE



It does the work of larger machines, costing much more.

- Pantograph is graduated with reductions from 1:1 to 100:1 and will reduce to any size to infinity.
- Pantograph and spindle link joints equipped with precision ball bearings throughout.
- Precision ball bearing cutter spindle
- Collet capacity from 1/10" to 1/4" and standard taper shank cutters
- Six spindle speeds—5,000 to 14,000 rpm
- All feed-screw dials graduated in .001"

TRADE MARK PANTO

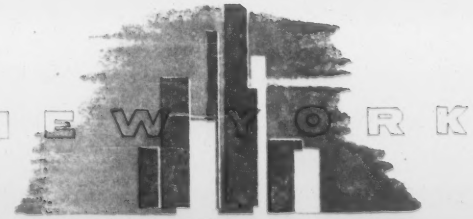
Write for complete details and prices. For immediate attention write directly to manufacturer below. Ask for nearest representative.

H. P. PREIS ENGRAVING MACHINE CO.
661 U. S. Highway 22, Hillside, N. J.

For more information circle **34** on inquiry card.

"the show of the future"

FIFTH INTERNATIONAL automation EXPOSITION



NOVEMBER 16-20, 1959

Plan NOW to exhibit at the Fifth International Automation Exposition

As the nation's leading "automation" show, the Fifth International Automation Exposition is ideal for displaying equipment, components, and systems associated with industrial and scientific instrumentation, machine-tool control, computing, data and materials handling, and conveying.

Scheduled for November 16 to 20, 1959, at the New York Trade Show Building, the Exposition will again attract thousands of top executives and technical personnel from all industries.

Unique features of the New York Trade Show Building enable all exhibitors to schedule "clinics" for instructing selected audiences on the fine points of their equipment . . . in complete privacy . . . and featuring the equipment itself!

Make room now, in your promotion budget, for this most important show. Write for full details, and breakdown of attendance at previous International Automation Expositions.

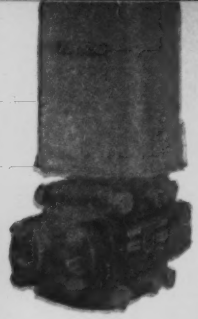
Richard Rimbach Associates, Management

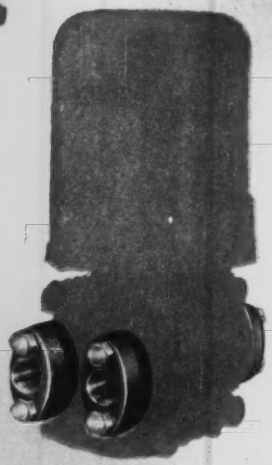
FIFTH INTERNATIONAL AUTOMATION EXPOSITION

845 Ridge Avenue, Pittsburgh 12, Penna. Phone FAirfax 1-9831 and 1-9832

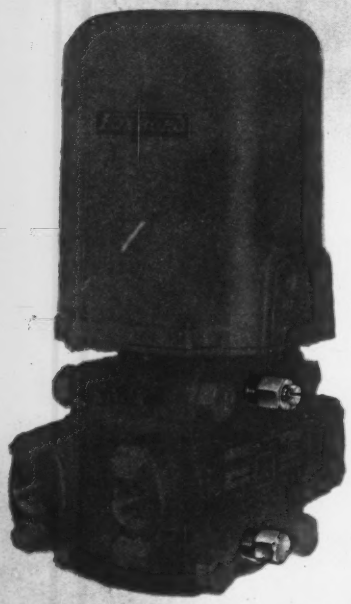
FOXBORO d/p CELL

unequaled –





Simplest installation — orifice flange tap connections at standard spacing, are provided at both ends.



Drain and vent holes at lowest and highest points on both sides.

Purged cover protects transmitter from weather, dust, and fumes.

Over 60,000 now in use!

No zero drift . . . positive overrange protection . . . high sustained accuracy even under the most punishing operating conditions. No wonder over 60,000 Foxboro d/p Cell Transmitters have been installed since they were introduced in 1948.

By introducing the modern concept of high speed flow measurement and control, these differential pressure transmitters have *revolutionized* many an industrial process. Bulletin 13-11A shows how — and portrays the benefits the d/p Cell Transmitter offers you. Write **The Foxboro Company, 462 Neponset Ave., Foxboro, Mass., U.S.A.**

FOXBORO

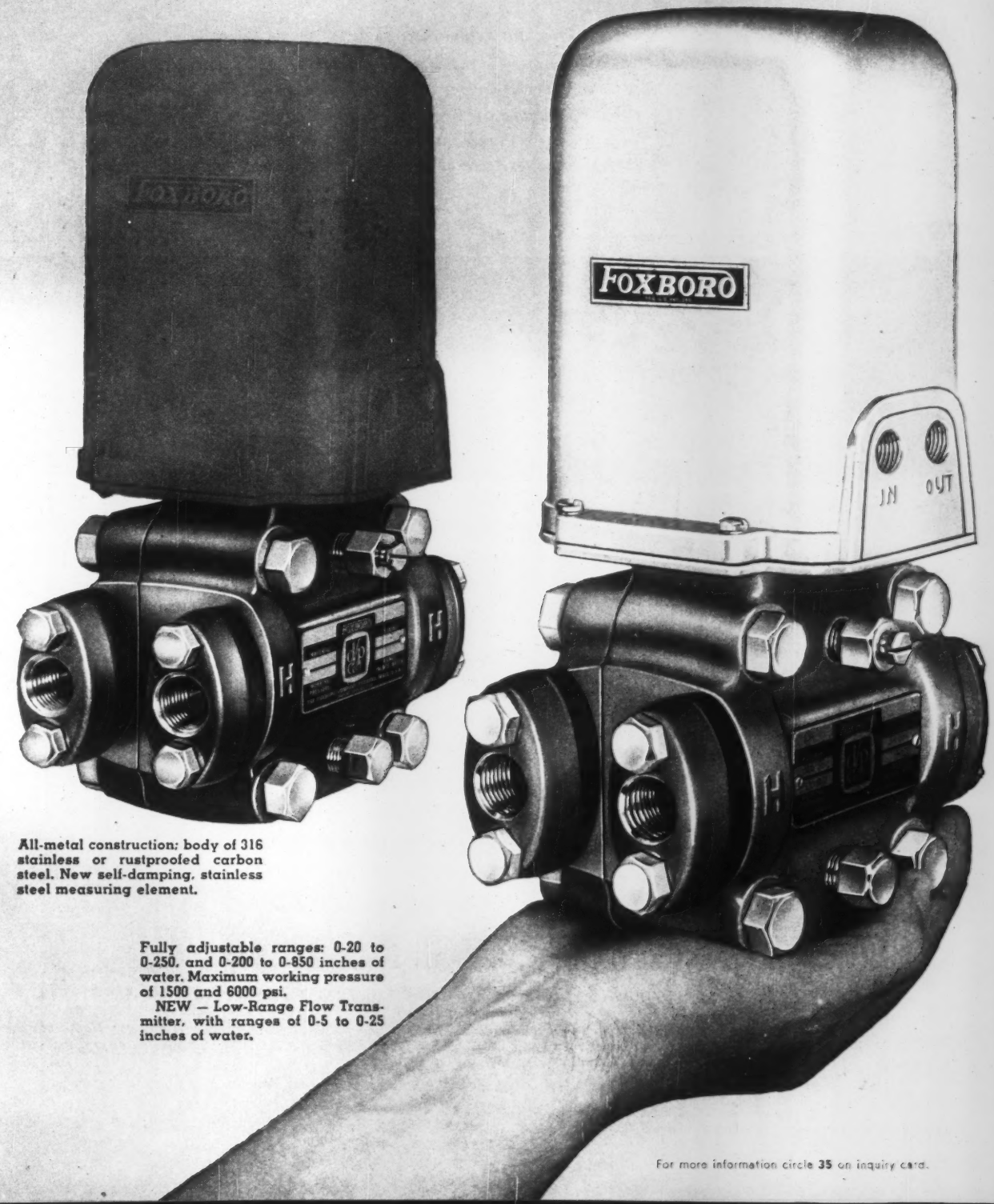
REG. U.S. PAT. OFF.

FIRST in Flow Measurement and Control

For more information circle 35 on inquiry card.

FLOW TRANSMITTERS...

in accuracy, stability and performance

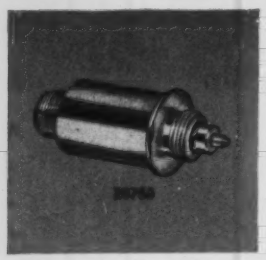


All-metal construction: body of 316 stainless or rustproofed carbon steel. New self-damping, stainless steel measuring element.

Fully adjustable ranges: 0-20 to 0-250, and 0-200 to 0-850 inches of water. Maximum working pressure of 1500 and 6000 psi.

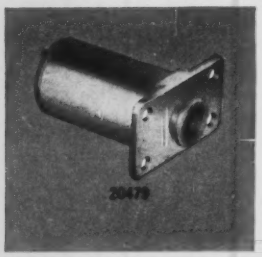
NEW — Low-Range Flow Transmitter, with ranges of 0-5 to 0-25 inches of water.

For more information circle **35** on inquiry card.



true hermetically sealed solenoids

Just like a sealed vacuum tube! True hermetic sealing around a solenoid . . . glass seal terminals, lugs, and connectors. All welded and brazed construction. Completely plated after assembly. Exceed most requirements of military specification MIL-S-4040 (USAF). Priced at approximately the same level as conventional types.



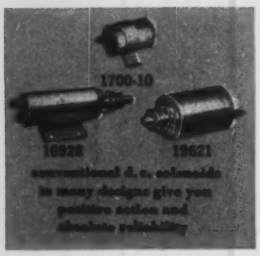
high-temperature solenoids

These modern new solenoids give you a reasonable life expectancy at temperatures as high as 350° C. A by-product of hermetic sealing. Class H insulation combined with inert gas filling add those necessary extra few degrees needed in your temperature limits . . . make these solenoids exceptional high-quality, high-temperature units.

D C solenoids

. . . and those unusual specialties you look for!

Having trouble finding solenoid specialties? Here at Cannon, we'd like to help you. Standard production now includes multiple-strip solenoids for keyboard operation, locking types requiring no holding current, and miniatures and sub-miniatures ½" diameter. In addition, our expanded solenoid engineering department is ready to serve you at any time.



CANNON PLUGS

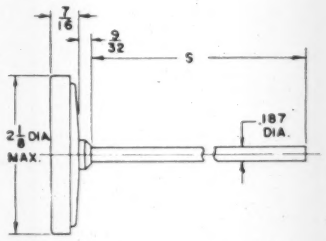
CANNON ELECTRIC CO., 3208 Humboldt St., Los Angeles 31, Calif.
Please refer to Dept. 419
Factories in Los Angeles, Salem, Mass., Toronto, London, Melbourne. Manufacturing licensees in Paris and Tokyo. Representatives and distributors in all principal cities. See your Telephone Yellow Book.

Please ask for latest SR-S releases and/or Solenoid Bulletin.

For more information circle **36** on inquiry card.

Bi-Metal Dial Thermometers

Where space limitations are a factor, these 2″ American Bi-Metal Thermometers are the solution to temperature indicating problems . . . They combine the unique anti-parallax Maxivision dial with an index type pointer adjustable over the entire range for

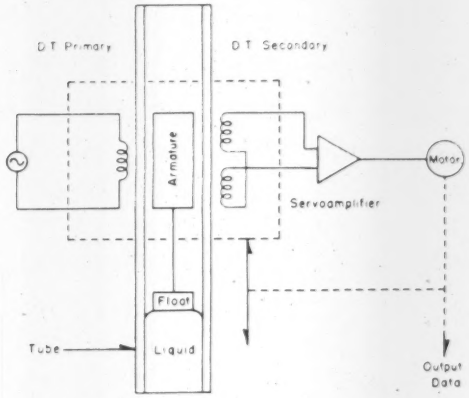


simple, quick recalibration . . . They are impervious to any climate or corrosive atmosphere due to the stainless steel construction of case, ring, stem and threaded hub. A resilient gasket between case and cover glass keeps out dust, dirt, rain, sand, fumes, and frost . . . (*From new 4-page Bulletin 152, Manning, Maxwell & Moore, Inc., Stratford, Conn.*)

For this literature circle **137** on inquiry card.

Servomanometers

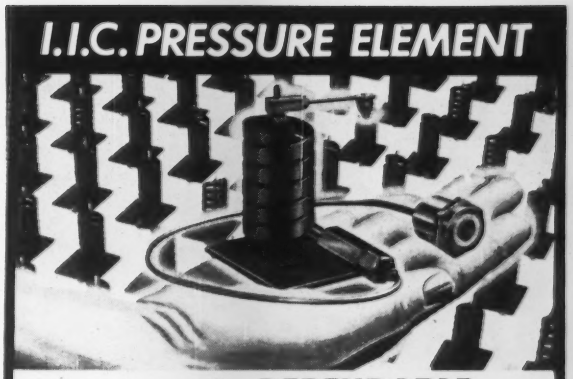
A differential transformer (DT) is continuously positioned by a servo to be electrically centered about a float containing magnetic material. A proportional shaft position in the servo transmission is then analogous to the position of the liquid column . . . Ac-



curacy ratings are based upon readout from a mechanical counter and data shaft position rather than a scale alongside the manometer tube.

Exceptional accuracy is provided. The principles employed afford a means to servo-follow at slew speeds of several hundred inches per minute, over a range of many feet at present temperature compensated data to a characteristic accuracy of 0.001 to 0.003″, as applied to measurements of length or actual manometer column height, and 0.002 to 0.010″ as applied to most manometer systems. (*From new 16-page Bulletin 500, Exactel Instrument Co., 5545 Eva Ave., Los Altos, Calif.*).

For this literature circle **138** on inquiry card.



. . . A DEPENDABLE PRESSURE ELEMENT!

MANUFACTURED IN ALL RANGES
0-15 P.S.I. to 0-10,000 P.S.I.

I.I.C. offers you a new dimension of accuracy, dependability and long life in a new Pressure Element. This Element's linearity and repeatability are constant assuring accurate recording.

Low maintenance and rugged construction in addition to the versatile quality of I.I.C.'s Pressure Element make it the very finest pressure element manufactured.

We Invite O. E. M. Accounts
Manufactured to Your Specification

INDUSTRIAL INSTRUMENT CORP.

8400 RESEARCH ROAD — AUSTIN TEXAS

For more information circle **37** on inquiry card.

FULL-TIME CALIBRATION

CVR-10 constant voltage reference supply replaces short-life dry-cells, simplifies maintenance, cuts down-time.

Many controlling, recording and indicating instruments use dry-cells for constant current in resistance bridge loads. Under high ambient temperatures dry-cell output often dwindles quickly. The CVR-10 eliminates battery replacement schedules and inaccuracies due to dry-cell drainage.

The CVR-10 has the same dimensions as a No. 6 dry-cell, which it is designed to replace with no instrument modification. With an output stability of 0.25% from 108 to 125 V ac input, output is 1.5 V with 6 MA current drain; CVR's are also available with other outputs.

Pm PERFORMANCE MEASUREMENTS CO.
15301 W. McNICHOLS ROAD DETROIT 35, MICHIGAN

For more information circle **38** on inquiry card.

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4607 Alger St., Los Angeles 39, Calif. • Tel. CHapman 5-3748
TWX Glendale, California 7025 • WUX Los Angeles, California

For more information circle **39** on inquiry card.

for AUTOMATED CONTROL, specify

Check the features of this new design:

- Rapid diaphragm action, no sliding parts
- Precise clutching and braking – adjustable "soft" to "harsh" action
- Simplicity in design, trouble-free operation
- Silent action, eliminates magnetization of surrounding parts
- 5 standard styles; full range of sizes — ⅞" to 3⅛" diameter

Check your requirements for electric clutch and brake control. You'll find SIMPLATROL Miniature and Small Electric Clutches and Brakes upgrade new machine performance, give faster, more precise sequence operations.

Ask for recommendations on Simplatrol units.
New illustrated folder on request.

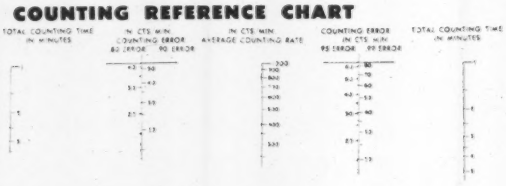
Simplatrol products corp.
24-8 SALISBURY ST., WORCESTER, MASS.
Representatives in Key Industrial Areas

For more information circle **40** on inquiry card.

BRIEFS—CONTINUED

Neutron Detector

To find the total counting time required to determine a given counting rate, with a given counting error . . . Example: Find the 0.8 error of a sample which averages 1,000 counts per minute when counted for 5 minutes. Place a straight edge so that it inter-

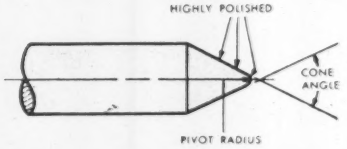


sects the left-hand total counting time scale and 5 and the counting rate scale at 1,000. It will intersect the 0.8 error scale at 18, the number of counts per minute for the .8 error . . . (*From new 32-page "Anton Neutron Detector Catalog", Anton Electronic Laboratories, Inc., 1226-1238 Flushing Ave., Brooklyn 37, N. Y.*)

For this literature circle **139** on inquiry card.

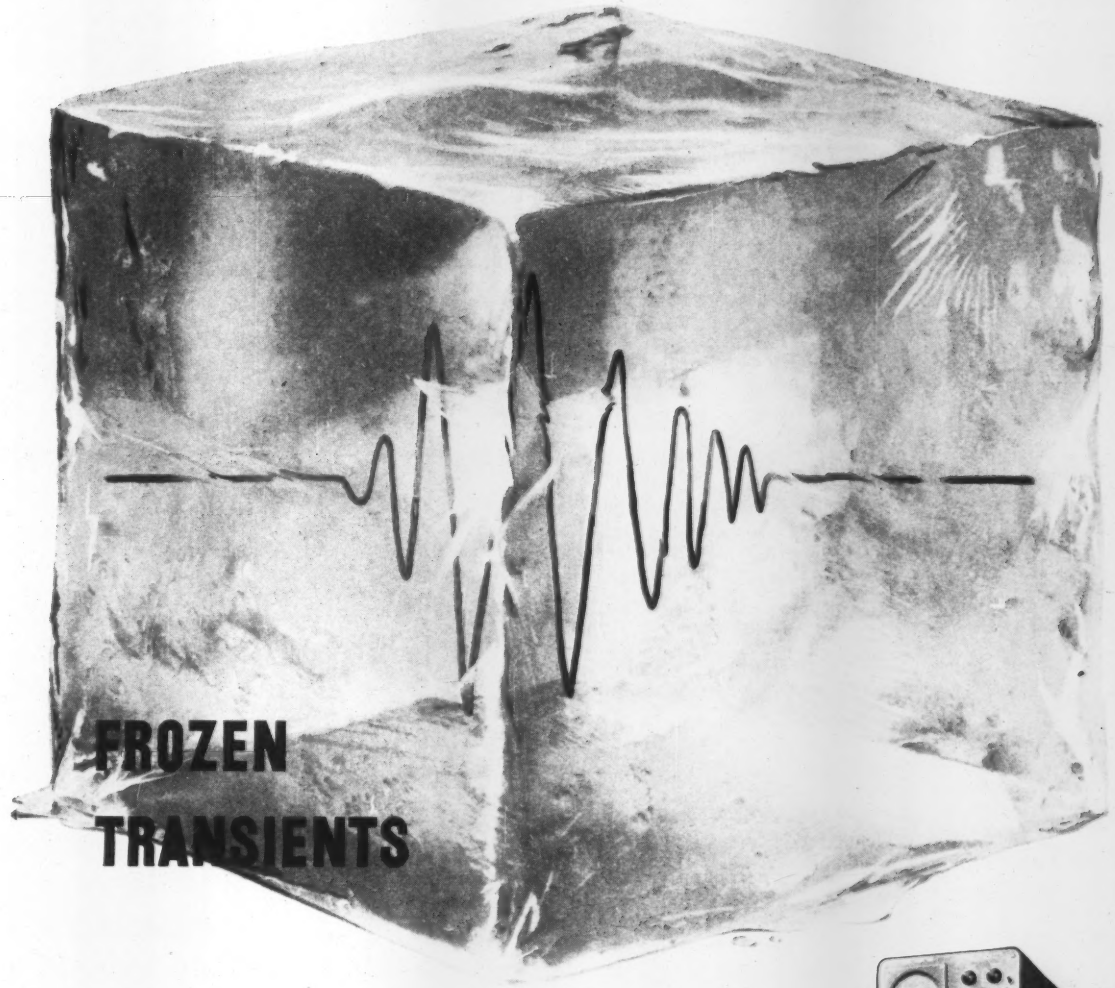
Jewel Bearings

One of the most common industrial applications of sapphire is its use as a bearing material in the horological and instrument field. Jewel Bearings support low torque moving systems with minimum frictional resistance to motion. Some of the other factors contributing to the wide use of sapphire as a bearing material are (1) miniature size, (2) very close tolerances, (3) excellent resistance to wear, (4) non-magnetic properties, (5) heat, corrosion and distortion resistance . . .

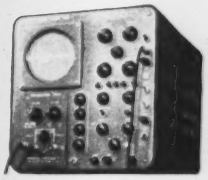


In addition to not having the impurities of the natural crystal, synthetic sapphire is available in sizes and shapes which were not provided by the natural source . . . Types: Industrial jewels are generally classified into five design-and-use catagories. The illustrations show basic types, however there are numerous possible contour modifications to meet specific applications . . . For best results, it is imperative that the contact area of the pivot be highly polished. The sapphire jewel bearing area is lapped to a mirror finish with the finest diamond powder available. At 45 magnifications, no scratches or surface defects should be visible on the bearing contact area. A well-polished finish of about 2-3 micro-inch on the pivot radius is recommended . . . (*From new 26-page Manual 5, Aurele M. Gatti Inc., 524 Tindall Ave., Trenton, N. J.*).

For this literature circle **140** on inquiry card.



with the Hughes MEMO-SCOPE® Oscilloscope



Trial and error methods necessary to capture elusive transients on conventional scopes waste time, film, and precious research dollars. Never again need this happen. With the Hughes MEMO-SCOPE® oscilloscope you may instantly "freeze" wave forms with brilliant clarity for careful study, comparison and analysis.

The Hughes MEMO-SCOPE® oscilloscope retains these frozen transients until intentionally erased. Selected transient information may be triggered externally or internally. Successive wave forms may be written above, below or directly over the original information.

SWEEP SPEED FOR STORAGE: 10 microseconds to 10 seconds per division (0.33").

FREQUENCY RESPONSE: DC to 250 KC down 3 db.

SENSITIVITY: 10 millivolts to 50 volts per division or with optional high sensitivity preamplifier 1 millivolt to 50 volts per division.

APPLICATIONS: Trouble shooting data reduction equipment ... switch and relay contact study ... ballistics and explosives research ... ultrasonic flaw detection ... physical testing — shock — stress — strain.

A Hughes representative will gladly demonstrate the MEMO-SCOPE® *oscilloscope in your company. Simply address your request to: Hughes Products, Marketing Dept.—*MEMO-SCOPE® *International Airport Station, Los Angeles 45, California*

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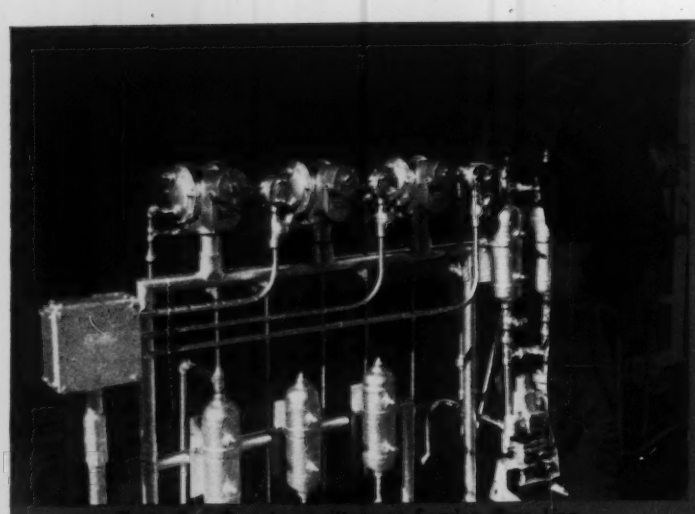
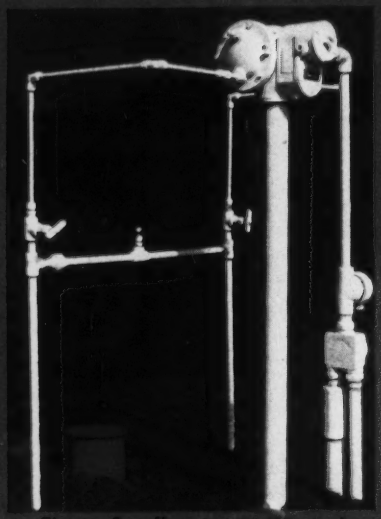
SEMICONDUCTOR DEVICES • STORAGE AND MICROWAVE TUBES • CRYSTAL FILTERS • OSCILLOSCOPES • RELAYS • SWITCHES • INDUSTRIAL CONTROL SYSTEMS

For more information circle **41** on inquiry card.

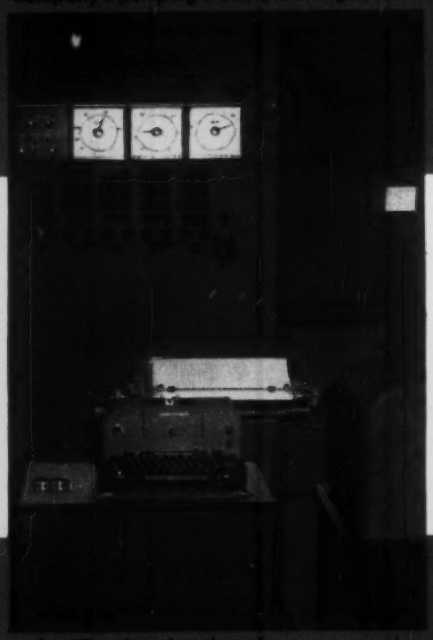
pressure and flow data



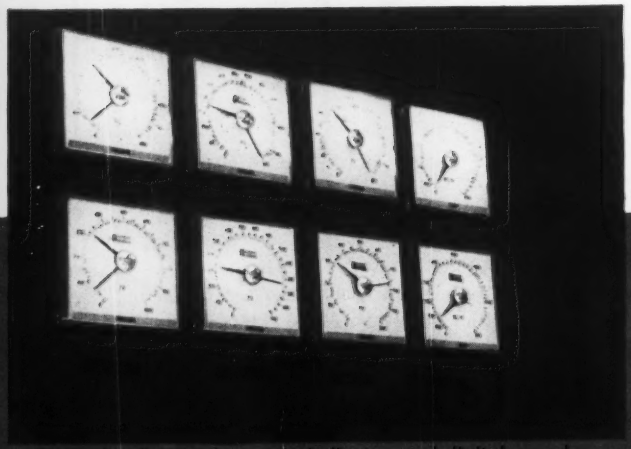
ElectroSyn flow transmitters at Service Pipe Line Company's pumping station, Drumright, Oklahoma.



ElectroSyn flow transmitters at Service Pipe Line's Blake Station (Washington County, Oklahoma).



Satellite data logging of pressures and flows at Drumright Station.



ElectroSyn flow and pressure indicators and digital encoders at Blake Station.

For more information circle **42** on inquiry card.

3 to 4 times more accurate with

NORWOOD CONTROLS

ELECTROSYN

Norwood Control's ElectroSyn transmitters are today playing an increasingly important role in the handling of pressure and flow data. The ElectroSyn System's digital approach automatically makes available — for logging — pressure and flow information with 3 to 4 times greater accuracy than can be attained by use of analog equipment. This increased accuracy results in considerably higher overall operation efficiency.

The ElectroSyn null-balance System consists of electro-magnetic transmitters and feedback units combined with magnetic amplifiers. Servo-indicators actuate adjustable high and low alarm contacts which are visible and can be set from the front of the instrument. Shaft positions of the servos are read out by encoders . . . linear encoders for pressure and square law encoders for flow. Additional encoders can be actuated to provide rate-of-change alarms.

ElectroSyn Systems are preferred by more and more companies in the processing, pipeline and atomic power fields because they offer:

- **Higher reliability**
- **Lower maintenance**
- **Flexibility of application**
- **Rugged electro-magnetic system**
- **Can withstand static overload of 200% of rated pressure with no zero shift**
- **Remote transmission**
- **Explosion-proof transmitters**

Write for ElectroSyn Bulletin B257 — Norwood Controls Unit, Detroit Controls Division, 937 Washington St., Norwood, Mass.

AMERICAN-Standard PRODUCTS

AMERICAN-Standard

DETROIT CONTROLS DIVISION

For more information circle **42** on inquiry card.

Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters
INLET PORT
DISCHARGE PORT
DISCHARGE PORT
INLET PORT
ROTATION IS CLOCKWISE

Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

No oil filters.
No dust filters.
No internal lubrication to contaminate air handled.
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
Low maintenance cost.

NASH ENGINEERING COMPANY
370 WILSON, SO. NORWALK, CONN.

Absolutely incredible... but absolutely true! For the first time ever, here is the *only* thermometer which covers a range from —100°C to 900°C, with .01°C sensitivity and digital reading of temperature directly.

read temperature directly · no calculations necessary

- ▶ High Accuracy
  .10°C up to 400°C .20°C up to 900°C
- ▶ Each resistance bulb and bridge individually calibrated.
- ▶ Vacuum sealed platinum elements and leads in resistance bulb:
  - Hermetically sealed head
  - Choice of stainless steel or quartz jacket
- ▶ Plug-in controller accessory with .05°C reproducibility.

ELECTRONIC Resistance Thermometer

HOW IT WORKS:

By means of a special circuit in the Wheatstone bridge, the reading of the balancing variable resistor is made to follow a second degree relationship corresponding with the change in resistance of platinum with temperature. This gives a direct reading instrument which eliminates the time consuming calculations normally required with high precision resistance thermometry. A high sensitivity electronic detector permits rapid and precise balancing of the bridge.

PRICE LIST:

23525	Electronic Resistance Thermometer without bulb. Either 23525D or 23525E or both must be ordered at the same time as the thermometer and these will be individually calibrated	**1105.00**
23525D	Stainless Steel Bulb, only	**395.00**
23525E	Quartz Bulb, only	**395.00**
23525F	Temperature controller, only	**112.50**

The EMIL GREINER Co.

For Complete Information Write For Bulletin

20-26 N. Moore Street, Dept. 230, N. Y. 13, N. Y.

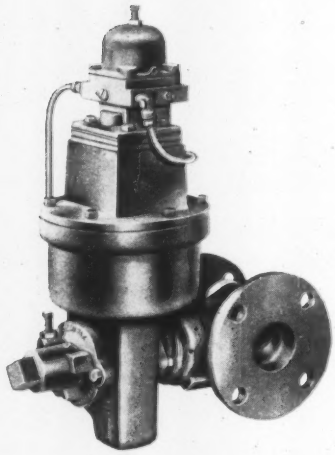
For more information circle **43** on inquiry card.

Straight-thru flow...
Drip-tight shut-off...
No stem leakage....

INTERESTED?

There's **More!**

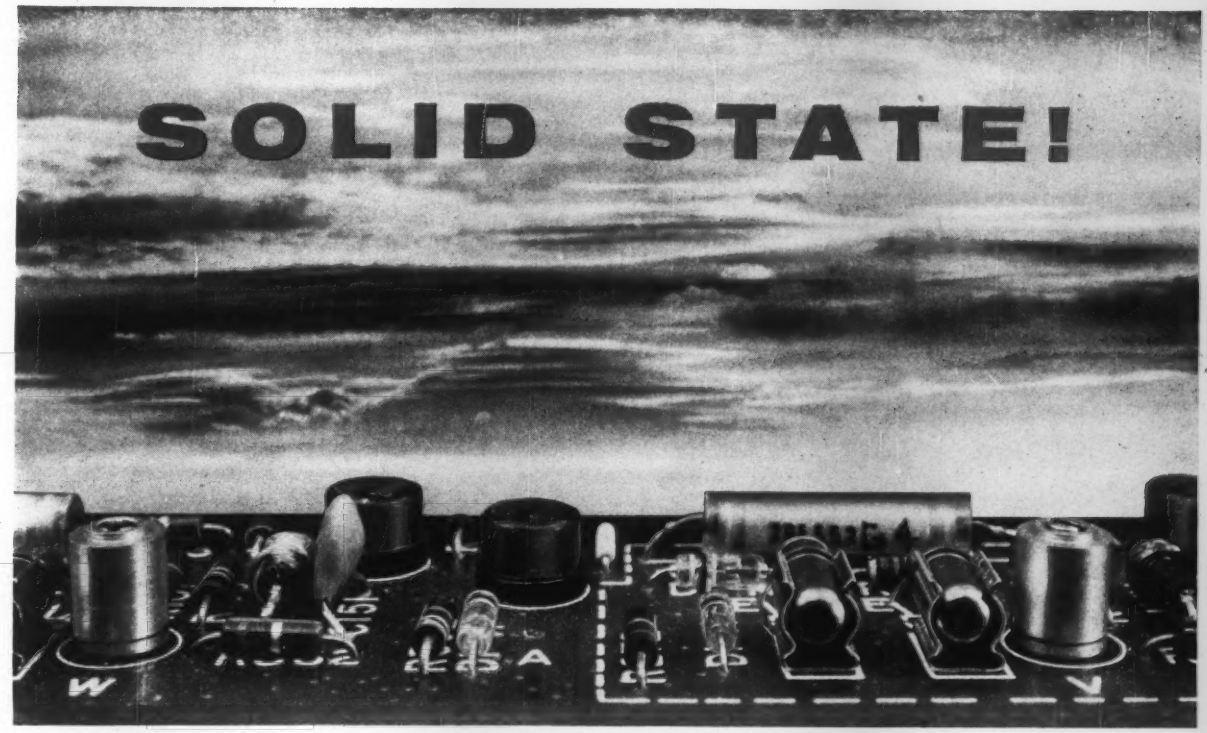
DeZurik Control Valves have a *number* of advantages over ordinary control valves. Because of its economical basic design, a DeZurik Control Valve can be supplied with a positioner often at a cost lower than an ordinary control valve without a positioner! Their straight-thru flow permits higher capacity with less turbulence. Their eccentric action and resilient plug facing shut dead tight! Every time—on *any* line! The rotary stem seal on DeZurik Valves completely eliminates stem leakage . . . the stem seal is under constant spring tension, never needs adjustment or lubrication.



DeZurik Control Valves are available in sizes ½" thru 20", in a complete range of metals and with a full line of operators. See the DeZurik representative in your area, or write for further details.

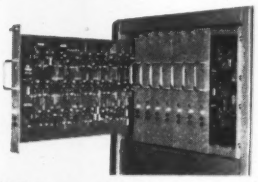
DeZURIK CORPORATION
SARTELL, MINNESOTA

For more information circle **44** on inquiry card.



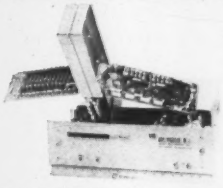
"New Look on the Horizon"—COMPLETELY TRANSISTORIZED

DIGITAL COMPUTERS, CONVERTERS, SYSTEMS AND MODULES



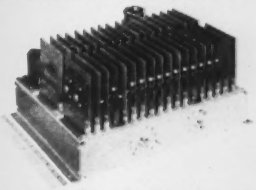
TRICE (Transistorized Realtime Incremental Computer, Expandable) — THE WORLD'S MOST ADVANCED COMPUTER

TRICE is a completely solid state high speed (100,000 iterations per second) incremental computer that operates at the speed of analog computers with the accuracy and flexibility of digital devices. Independent computing elements, operating in parallel, permit the computer's size to be adjusted to meet varying applications. Completely digital, TRICE can be used in simulating nonlinear and open loop systems without the limitations of analog methods. Because of its very high speed, it is particularly applicable to various operational systems including the computation of coordinate transformations, missile trajectories, Fourier spectra and satellite orbits.



MULTIVERTER—Voltage-Digital Converter and Related Products

The MULTIVERTER was developed by Packard Bell Computer to meet industry's need for fast, accurate and reliable conversion between voltage and digital information representation for use in data collection and transmission systems, in digital control systems and in interconnecting computers such as TRICE with analog devices. The MULTIVERTER is the first completely solid state high speed (4 microseconds per bit) conversion system accurate to .01%. Accessories include a compatible solid state multiplexer and the first high speed solid state Sample and Hold device.



TRANSISTORIZED AND MAGNETIC DIGITAL MODULES

A variety of solid state modules are available for the construction of special systems. The following transistorized types are available: medium speed (nominally 200KC) AC coupled modules, high speed (nominally 4 mc) AC coupled modules, medium speed DC coupled modules, special high temperature modules and magnetic modules at low (20KC) and medium (100KC) speed together with the *first* commercially available *transistor* driving circuits.

CUSTOM DIGITAL CONTROL AND COMPUTING SYSTEMS

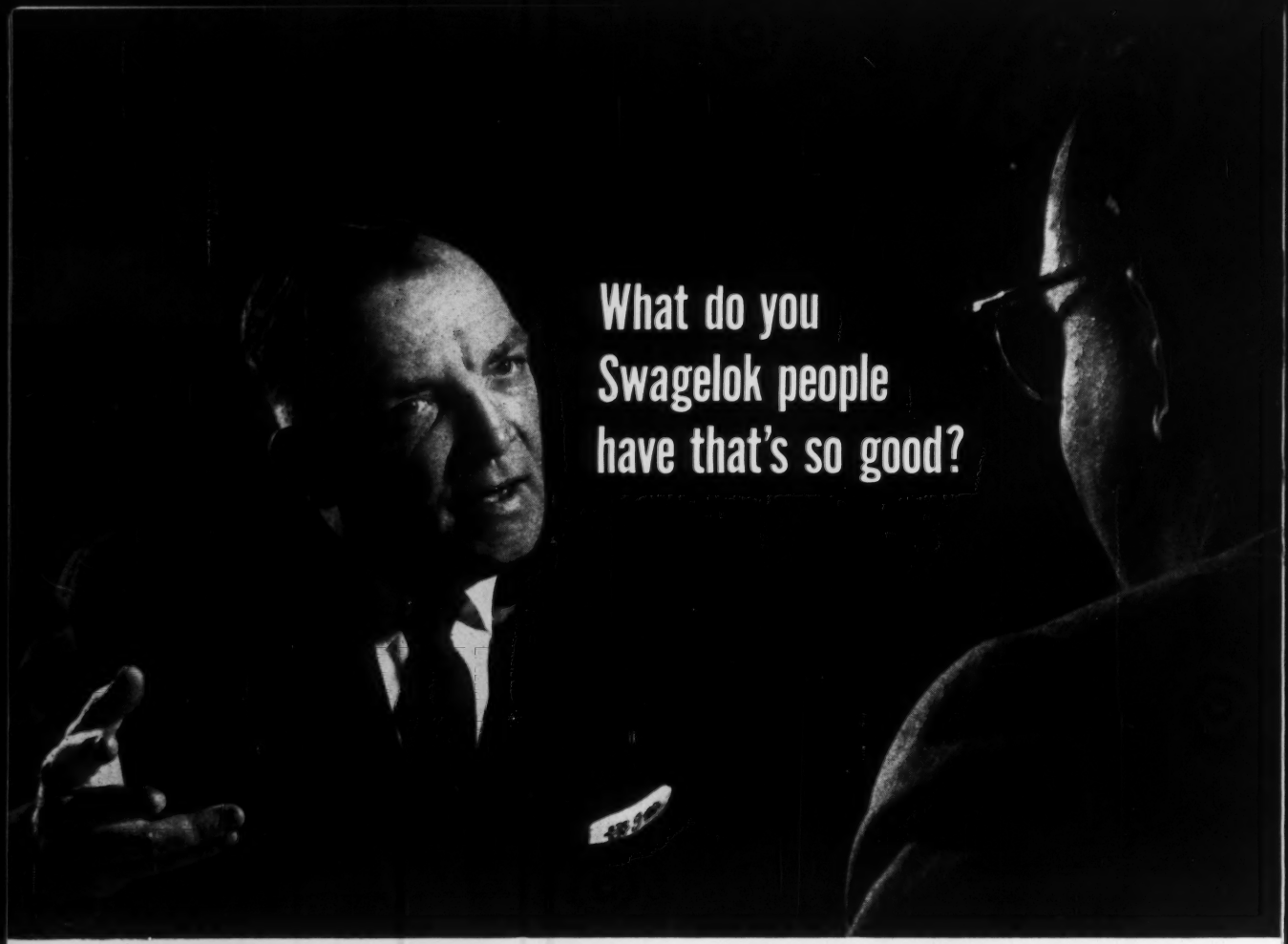
Packard Bell Computer uses the components and techniques described to produce custom digital systems for Missile Impact Prediction, On Line Data Processing, Data Recording, Coordinate Conversion, Stable Platform Calculations, Orbit Predictions, Guidance and Control and Solid State Automatic Checkout.

PACKARD BELL COMPUTER CORP.

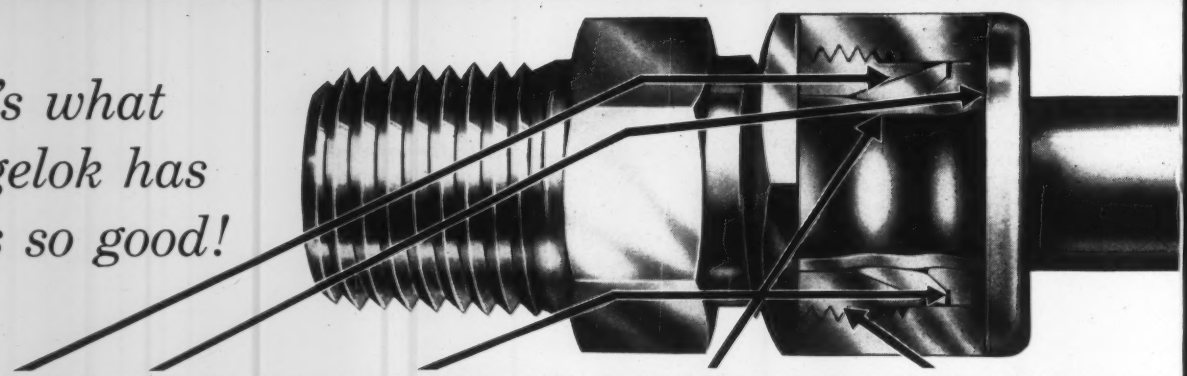
A subsidiary of Packard Bell Electronics

1905 S. Armacost Ave. • Los Angeles 25, California • GR 8-4247

For more information circle 45 on inquiry card.



Here's what Swagelok has that's so good!



1. LEAKPROOF SEAL. Patented Swagelok design assures positive leakproof seals at 3 different contact points to hold extreme pressures and vacuums.

2. VIBRATION-FREE. Swagelok design enables fitting to firmly grasp tubing with two ferrules and a threaded chuck, assuring practical distribution of contact forces and maintaining vibration-free rigidity.

3. TORQUE-FREE. The positive 3-point sealing contacts in the Swagelok tube fitting attain top operating efficiency with only 1¼ turns of the tightening unit. Absolutely no torque is transmitted to the tubing in assembly.

4. CONSTRICTION-FREE. Because of the scientific distribution of the 3 leakproof contact points in the Swagelok design, there is practically no constriction of the inner tube wall, so that turbulence is negligible on heavy or thin wall tubing.

5. QUICK ADAPTABILITY. Swagelok tube fittings come to you completely assembled, finger tight, ready for immediate use. Simply slip the tubing into the Swagelok fitting, give the nut 1¼ turns, and the assembly is ready for assured, leakproof service.

In Swagelok tube fittings, there is nothing finer that man's ingenuity and precision machinery can produce.

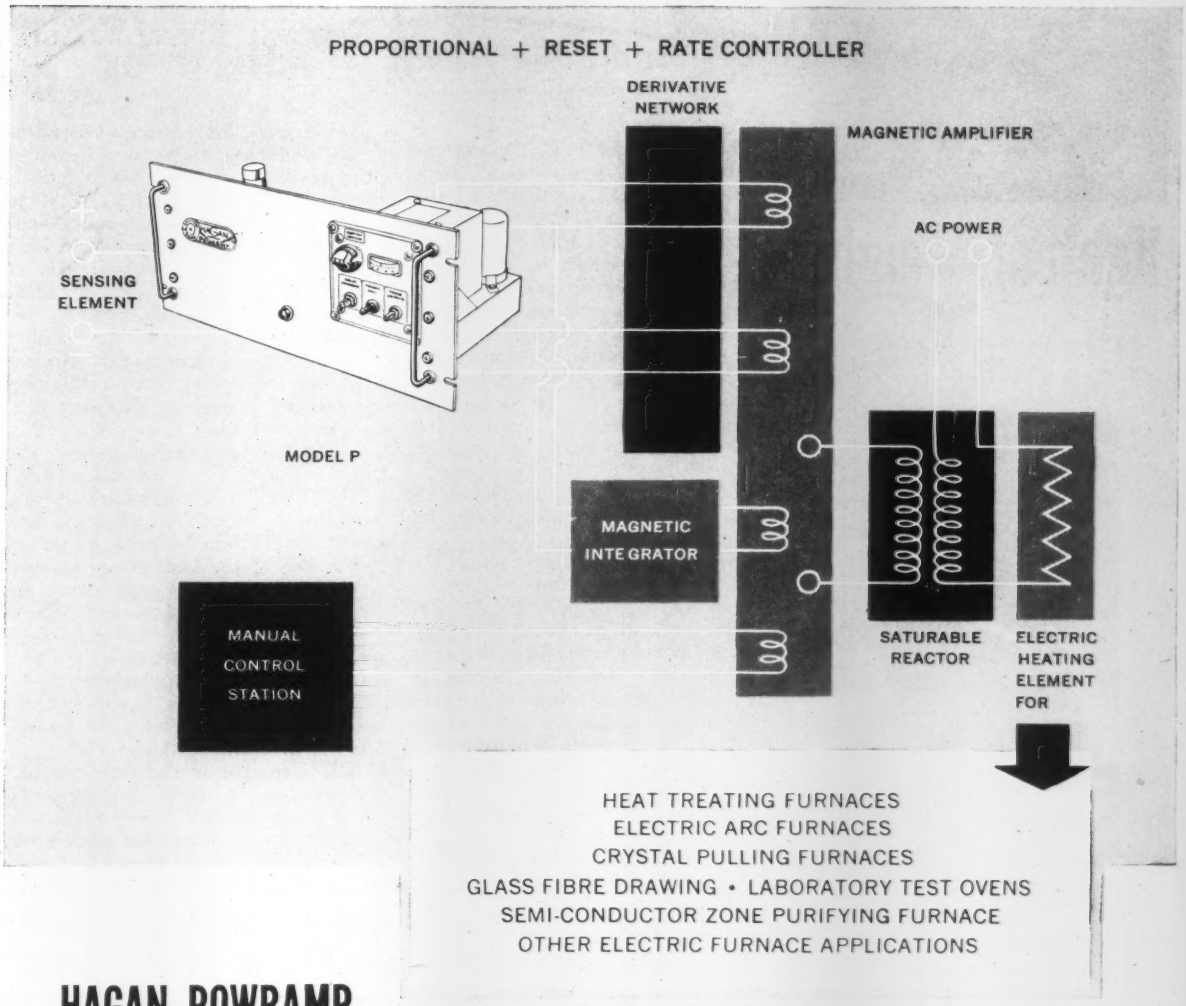
Swagelok is the one name that stands apart from all the others in the field... outstanding and unique in concept, craftsmanship and leakproof performance in extreme service.

Swagelok engineers are equipped with experience, ability, and wide range of tube fitting designs to meet your individual problems. Quick delivery of Swagelok tube fittings from local distributor stocks.

Swagelok® TUBE FITTINGS

CRAWFORD FITTING COMPANY
884 East 140th Street • Cleveland 10, Ohio
Crawford Fittings (Canada) Ltd., Stamford, Ontario, Canada

For more information circle **46** on inquiry card.



HAGAN POWRAMP

All Electronic TEMPERATURE CONTROLLER

all electronic—set point resolution—0.1% of range—handles up to 330 kva

Small in size and economical in cost, the Hagan PowrAmp Temperature Controller is a precision control system for all types of electric heating applications. Using the PowrAmp Model "P" for initial amplification of the sensing element signal and magnetic amplifiers for summing and integration, this Hagan controller virtually eliminates the need for periodic maintenance.

Proportional band, reset and rate action are all available to fit process requirements. The Hagan Temperature Controller has a precision digital set point, and provides stepless fractional degree regulation, even at high temperature levels.

The Hagan controller is particularly valuable in precise temperature applications where either the heater or the product temperature can change rapidly. The Controller is part of the Hagan PowrAmp line which includes transducers for most key variables, electronic control computers and high power electro-hydraulic servo valves. Write for Bulletin MSP-133, which describes the full PowrAmp line.

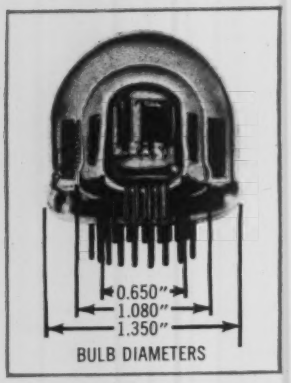
For additional information on the Hagan Temperature Controller, write for Specifications Sheet GE 60001.

HAGAN CHEMICALS & CONTROLS, INC.
DIVISIONS: CALGON COMPANY, HALL LABORATORIES
HAGAN BUILDING, PITTSBURGH 30, PA.
In Canada: Hagan Corporation (Canada) Limited, Toronto

For more information circle **47** on inquiry card.

Burroughs
NUMERICAL
READOUT TUBE
NIXIE®

lightest weight
any
readout



ALL ELECTRONIC IN LINE READOUT
CONTAINING TEN DIGITS "0" THRU "9"

MINIATURE	STANDARD	SUPER
0.2 oz.	0.4 oz.	0.8 oz.

NIXIE TUBE EXCLUSIVE FEATURES:

- ALL ELECTRONIC
- LOWEST COST
- LOWEST POWER
- MOST READABLE FOR NUMBER SIZE
- SMALLEST VOLUME ANY NUMBER SIZE
- MAXIMUM TEMPERATURE, SHOCK AND VIBRATION SPECS

Electronic components of
Burroughs Corporation
ELECTRONIC TUBE DIVISION
Plainfield, New Jersey

For more information circle 48 on inquiry card.

panhandle pete

New SSE Div. of WESCO!

"WE HAVE to face up to some serious problems," says Bus, 4-Card Wallace, our Chief Engineer, at the monthly management meeting of WESCO! "Somebody—not our salesmen or anybody we know, of course—has been overselling the systems concept and we now have fifteen systems in the field. The fine results from our one system that is working is now nationally known because of the wonderful magazine coverage we have had, but we are having a hard time keeping the news about the other fourteen installations out of the papers."

"Wha's a matter?" asks Waldo, as if he don't know.

"Well, look at that new job at the Hula-Hoop factory. Here we put in a system that was to turn out 478,999 Hulas per hour, complete with data processing, automatic cost accounting, plus efficiency readout. Included in the system was a 42-station bending and bolting transfer line with counter-controller-computer-logger-monitor-annunciator.

"The machinery was installed in time, but one wrong drawing got 25 of the 42 automatic transfer operations a little out of line—only 1/8", but the hoops just wouldn't go through the machine; unfinished hoops just kept rolling out of the middle of the machine at a rate of 478,999 per hour. The automatic efficiency computer worked fine—it reported 0.0000% efficiency to four places. While new clamps for the machinery were being designed, 2600 workers had to be hired to feed the hoops along the line by hand.

"The hoops finally got out okay, but a squabble developed between the new workers and the old workers, who had different unions, and the plant was shut down for a month. When it opened up the machinery plus the instrumentation operated perfectly, but the market had disappeared. The total investment for this system was $2,650,000—which fortunately is only 96% loss because of the scrap value of the metal.

"Each of the other fourteen systems are having different troubles"—but you get the idea. The instruments work fine—but either the clamps, welders, bolters, conveyors, guides or something foul up the system just enough to destroy our cost picture. And who gets blamed—us systems men!"

"That ain't fair," says Waldo, who occasionally is very bright. "But what can we do about it?"

"We have looked into this carefully and have found the answer—the purchaser in each case underestimated the over-all task. What is needed is the total—or systems—approach to the systems problem. This is obviously a systems problem. It means not only "rethink" but "thruthink." Although everybody rethought their systems, they didn't thruthink them. Automation requires not only rethinking but thruthinking—detailed long-range planning".

"Say that again", says Waldo.

"Thruthinking, thruthinking, you fool," says Bus. "Long-range planning. In other words, where do you get the second million when the first is spent. This is basically a systems approach to the systems approach—the systems systems engineering approach. This calls for a new division—the SSE Division of WESCO! Industry is at the crossroads; the SSE Division will tell them where to go."

"And just what will our SSE Division do,"? asks Waldo, who really is not an executive type.

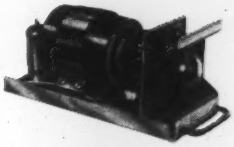
"Waldo, you are slightly stupid," replies Bus. "First, we will supply labor at any time and in any quantity to replace the machines that don't work. There will be a tremendous labor market wherever a new automation system goes into operation. While these workers are rushed into the breach, our Systems Systems Division will design a new system for complete automation of the systemated plant."

"For example, suppose a plant has 400 employes. An automated operation will give five times the production with only 40 employes. As soon as something happens to production in that automated plant, up to 5 x 400, or 2000 employees are required to operate that plant at the top volume while the system is down for repairs. WESCO will supply that labor while it is designing a new and bigger automatic system for that plant. As soon as the new equipment goes into the plant, the process repeats.

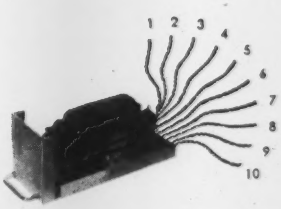
"If you will examine the figures you will see that more labor is required to replace machines than is displaced by machines. Further, every system installation in the country is a new prospect for a bigger system."

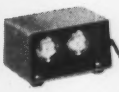
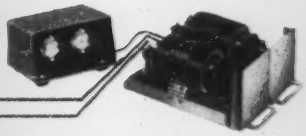
"Beautiful," sighed Waldo, "just beautiful—and in each case more labor is used than ever before while bigger systems are always in the works. You have truly thruthunk this problem."

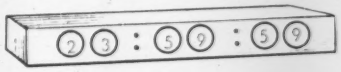
Panhandle Pete

NO OTHER  COUNTERS PROVIDE

DIRECTLY

TEN INDIVIDUAL OUTPUTS 

MULTIPLE REMOTE  READOUT 

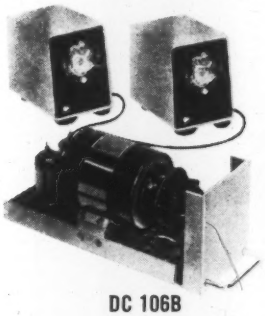
VARIABLE COUNT 

① ③ ⑤ ② ⓪ ⑨ IN-LINE READOUT

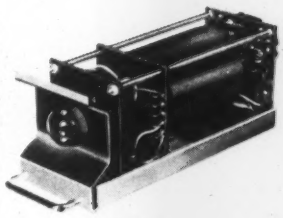
Burroughs **Visual and Electronic Error Free** Decade Counters are based on the unique properties of the Beam Switching Tube wherein a single cathode controls an electron beam to 10 outputs. In contrast to other types of counters, the Beam Switching Tube output is directly capable of driving an in-line indicator such as the Nixie® Tube. This complete line of seven counter types is designed for maximum reliability while providing advanced electrical characteristics not readily obtainable with other components. Such features include:

- Ultra reliable operations at one megacycle and over
- Electronic resetting in less than 1 microsecond
- Electrical output in each of its 10 positions
- Provisions for BOTH LOCAL AND REMOTE INDICATORS
- Extreme noise insensitivity
- Minimum components and power consumption

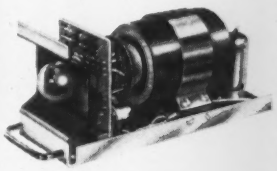
Write for eight pages of circuit information — Bul. 826A.



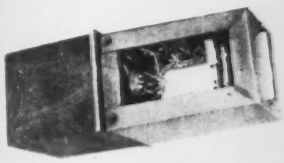
DC 106B



DC 101



DC 105, DC 106A



DC 130 — Mil Spec Counter

ANOTHER ELECTRONIC CONTRIBUTION BY

Burroughs Corporation

ELECTRONIC TUBE DIVISION

Plainfield, New Jersey

For more information circle **49** on inquiry card.

CRESCENT

POLYETHYLENE INSTRUMENT TUBING

Costs Less—Is Easier To Install

SIX DIFFERENT TYPES TO MEET YOUR SPECIFIC NEED

CRESCENT POLYETHYLENE MULTITUBE is 2 to 37 precision Polyethylene tubes *spirally cabled* together for greatest flexibility. The tubing assembly is protected against mechanical injury by an interlocked galvanized steel armor, Polyvinyl Chloride sheath, or other sheaths, as below.

CRESCENT POLYETHYLENE PRECISION INSTRUMENT TUBING

TYPE P is manufactured from the best high molecular weight virgin Polyethylene compound and TYPE XP of high modulus virgin Polyethylene compound selected for their superior resistance to environmental stress cracking and aging. Extensive research, improved manufacturing methods and rigid test standards have developed CRESCENT Polyethylene tubing to its present level of highest quality. It is furnished as single tubing in ¼", ⅜" and ½" sizes in up to eight bright colors. It is used exclusively in manufacturing CRESCENT POLYETHYLENE MULTITUBE in types as follows:

STANDARD TYPES

TYPE PA—Interlocked metallic armor provides complete mechanical protection.

TYPE PAT—Polyvinyl chloride sheath over the armor adds corrosion protection for the armor. Can be buried in the earth.

TYPE PT—PVC sheath gives limited mechanical protection. For use in troughs, trays or conduit.

SPECIAL SERVICE TYPES

TYPE XPT-U—Extra heavy PVC sheath over high modulus TYPE XP tubing permits direct burial, or use above ground where subject to moderate abuse.

TYPE XPT-F—Same as XPT-U with heavy asbestos braid and outer PVC sheath. Provides time delay in event of flash fire.

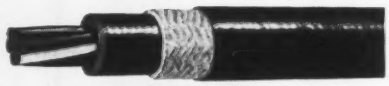
TYPE XPT-FA—Same as XPT-U with heavy asbestos braid and interlocked metallic armor. Provides complete mechanical protection, as well as time delay in event of flash fire.

TYPE PA

TYPE PAT

TYPE PT

TYPE XPT-U



TYPE XPT-F

TYPE XPT-FA

Write for complete information on these types, as well as types employing copper or aluminum tubing.

Ask for new bulletin No. 458-A

CRESCENT INSULATED WIRE & CABLE CO., INC.

TRENTON, NEW JERSEY

For more information circle **50** on inquiry card.

CASE HISTORIES

Frequency Time Standard instruments, selected by Smithsonian Institute to clock satellites, are equipped with New Departure ultra-precise ball bearings.

Photos: Courtesy Ernst Norman Laboratories and Bodine Electric Co.

Ultra Precise Ball Bearings Help "Clock" A Satellite!

CUSTOMER PROBLEM:

Require ultra-precise bearing design for Bodine electric motor used in satellite-tracking micro-clock. Bearings must provide uniformly low starting torque, precise location of rotor shaft and minimum maintenance, to help mechanism achieve time determinations to 0.001 second.

SOLUTION:

N/D Sales Engineers studied special bearing requirements, and recommended New Departure ultra-precise ball bearings. These ball bearings measured up to every requirement for micro-clock motors . . . thanks to New Departure's advanced equipment for research, development and production. N/D equipped micro-clocks, selected by the Smithsonian Institute, are operating in a dozen locations around the world right now, keeping track of vital satellite movements . . . to accuracies of one millisecond and better!

If you're manufacturing or designing electric motors for any high precision applications, including instruments, why not call on New Departure? N/D engineering and research facilities are turning out the latest in high precision instrument ball bearings and advanced ball bearing designs. For more information write Department I-2.

NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

For more information circle **51** on inquiry card.

Your *FISHER/MAN* offers you

SPEEDY DELIVERY

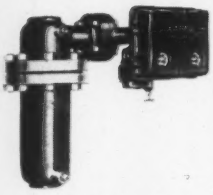
From the Factory Stocked

FISHER SUPERMARKET

Where you can shop by phone, wire or TWX

Type 657-A with 3500 positioner

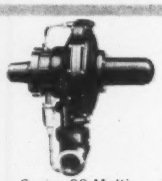
Type 4150 and 4160 Wizard II Pressure Controllers



Series 2500-249 and 2500-259B Level-Trols

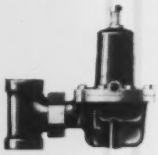
Type 95-H Pressure Reducing Valve

Type 630 "Big Joe" Field Regulator

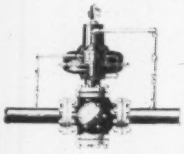


Series 99 Multi-Purpose Gas Regulators

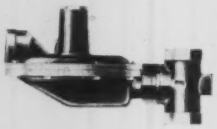
Type 655-A Pressure Regulator



Series 620 and 621 Farm Tap Regulators

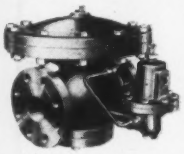


Series 298T Gas Regulators



Series S100 and 730 Service Regulators

Series 67FR Combination Filter-Regulator



Type 92B Pilot Operated Steam Reducing Valve

This "supermarket" availability of Fisher Control Valves and Controllers makes your delivery problems a thing of the past. Fisher keeps a stock of the equipment at left always on hand ready to ship to you at hourly notice. This means emergency requirements are met without costly delivery delays. This stock of control equipment includes all the most popular types in standard sizes.

In addition to the large factory stock, the Fisher offices in the column to the right which are starred carry a big selection of Fisher equipment in inventory to assist you.

Fisher constantly reviews the stock carried in the Supermarket and adds new items from time to time when your needs indicate.

Phone, wire or TWX (Marshalltown 578 or 579) and Fisher will have your order en route in a matter of hours, Saturday and Sunday excepted.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD...CHANCES ARE IT'S CONTROLLED BY...

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / London, England

CONTINENTAL EQUIPMENT CO. DIVISION, Coraopolis, Pennsylvania

FISHER® Controls

SINCE 1880

For more information circle **52** on inquiry card.

Now, for emergency needs contact FISHER or the representatives listed below.

*AMARILLO
Vinson Supply Company
*ATLANTA
J. M. Smither & Company
BALTIMORE
The Rhodes Controls Company
BIRMINGHAM
Joseph W. Eshelman & Company
BOSTON
Clarence B. Petty & Company
BUFFALO
W. J. Sommers Company
*CALGARY-EDMONTON
Barber Engineering & Supply Company
CARACAS, VENEZUELA
Sinclair Spence
*CHARLOTTE
Robert E. Mason & Company
CHICAGO
General Meters & Controls Company
CINCINNATI
H. T. Porter Company
*CLEVELAND
A. E. Ehrke & Company
*DALLAS
Vinson Supply Company
*DENVER
Joy & Cox, Inc.
*DETROIT
DuBois-Webb Company
*HOUSTON-CORPUS CHRISTI
Puffer-Sweiven Company
INDIANAPOLIS
Acme Engineering Agency
KANSAS CITY
Sullivan-Mears Company
*LOS ANGELES
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MEMPHIS-NASHVILLE
Johnson & Scott
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R. G. Read & Company
MONTREAL
Process & Steam Specialties, Inc.
*NEW ORLEANS-LAFAYETTE
John H. Carter Company
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*SAN FRANCISCO
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*SEATTLE
Power & Controls, Inc.
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*TULSA
Vinson Supply Company
VANCOUVER
Northern Columbia Process Equipment Company
*WICHITA-LIBERAL
Sullivan-Mears Company
WINNIPEG
Mechanical Valve & Engineering Spec.

events

March 11-12

Ninth Conference on Instrumentation for the Iron & Steel Industry, Hotel Roosevelt, Pittsburgh, Penna. For information write Robert Blackwell, Hagan Chemicals & Controls, Inc., P.O. Box 1346, Pittsburgh 30, Penna.

March 18-20

Twenty-Second Annual Short Course for Superintendents and Operators of Water and Sewerage Systems, on campus of Louisiana State University. For information write Fred H. Dean, Louisiana State University, Baton Rouge 3, Louisiana.

March 23-26

I.R.E. National Convention, New York Coliseum & Waldorf-Astoria Hotel, N. Y. For information write W. C. Copp, IRE Adv. Dept., 72 W. 45th St., N. Y. 36, N. Y.

March 26

Fifteenth Annual Quality Control Clinic, Rochester Society for Quality Control, University of Rochester, N. Y. Write Earl D. Hogan, Eastman Kodak Co., Kodak Park Works, Eng. Div., Bldg 23, Rochester 4, N. Y.

March 26-27

Eighth Annual Instrument Short Course, Los Angeles Harbor Junior College, Wilmington, Calif. For information write J. F. Ricketts, Southern California Meter Association, 350 S. Atlantic Blvd., Monterey Park, Calif.

March 30-April 3

Short Course on Strain Gage Techniques, Southwest Research Institute. For information write M. M. Lemcoe, Southwest Research Institute, Box 2296, San Antonio 6, Texas.

April 14-15

Conference on Industrial Instrumentation and Control, Illinois Institute Of Technology, Chicago, Ill. For information write R. W. Bull, Illinois Institute of Technology, 35 West 33rd St., Chicago 16, Ill.

April 16-17

Reliability Symposium, sponsored by Boston Sec., A.S.Q.C., Statler-Hilton Hotel, Boston, Mass. For information write Bob Fabian, Keystone Camera Co., 16 Hallet Sq. Dorchester, Mass.

May 6-8

1959 Electronic Components Conference, IRE, EIA, AIEE and WCEMA, Benjamin Franklin Hotel, Philadelphia, Pa. Write Bernard F. Osbahr Electronic Industries, Chestnut & 56th Sts., Philadelphia 39, Pa.

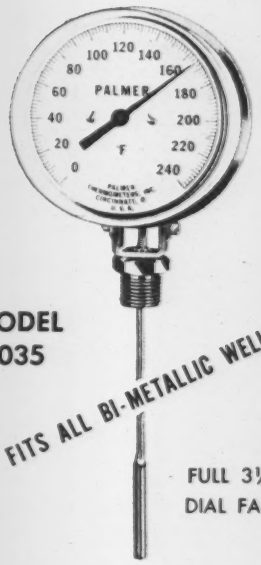
November 16-20

Fifth International Automation Exposition, The New York Trade Show Building, 500 Eighth Ave., New York City. For information write Richard Rimbach Associates, Mgmt., 845 Ridge Ave., Pittsburgh 12, Penna.

Outstanding Accuracy

PALMER

Dial Thermometer



Check these functional features

- Direct-drive Bourdon Coil with a filled system for longer lasting accuracy.
- Stem can be placed at any desired angle and case can be rotated to most readable position.
- External calibration for zero setting.
- Unaffected by stem alignment.
- Accurate to one scale division.
- No sticking at any temperature.
- Non-corrosive case.

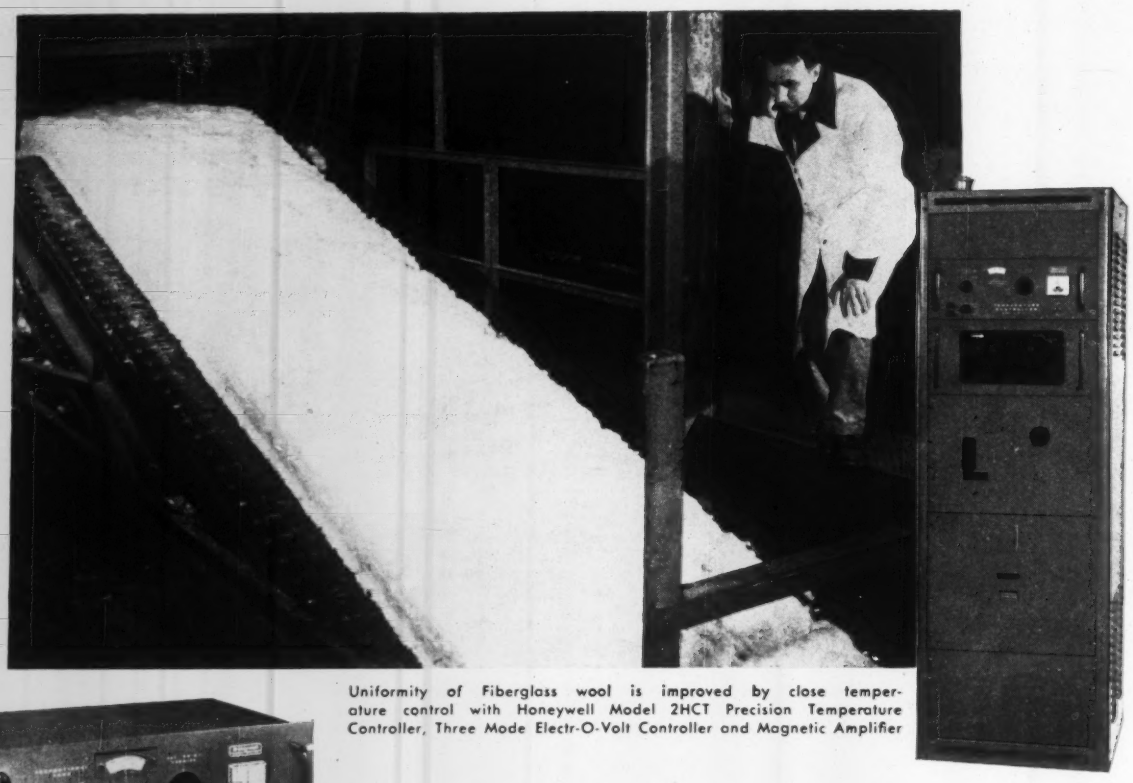
PALMER

THERMOMETERS, INC.

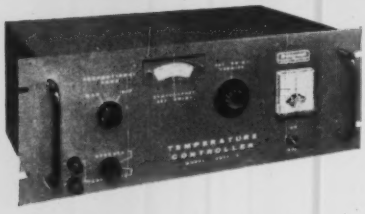
Mfrs. of Industrial Laboratory, Recording and Dial Thermometers

2515 Norwood Ave., Cincinnati 12, O.

For more information circle 53 on inquiry card.



Uniformity of Fiberglass wool is improved by close temperature control with Honeywell Model 2HCT Precision Temperature Controller, Three Mode Electr-O-Volt Controller and Magnetic Amplifier



Model 2HCT-2, single range control unit with direct reading analog dial, is available in a wide variety of ranges for any millivoltage or thermocouple input.

- No moving parts . . . magnetic converter input
- No stray electrical pickup . . . 60 cycle rejection of greater than 6×10^9
- Continuous automatic standardization
- Sensitive to change of less than 1 μv
- Full output power for 12 μv input deviation from set point
- Three-mode control available using Honeywell Electr-O-Volt

Temperature Control within 0.05% with new Honeywell Temperature Controller

The new Honeywell Precision Temperature Controller, series 2HCT, operates magnetic amplifiers and similar devices for control of saturable core reactor furnaces whose temperature can be measured with thermocouples.

The 2HCT consists of a null balance input circuit with manually adjusted set points and a highly stable d-c amplifier. The difference between the thermocouple signal and the set point is amplified 100,000 times to operate control circuits. Proportional band adjustment permits a decrease of sensitivity by a factor of 10.

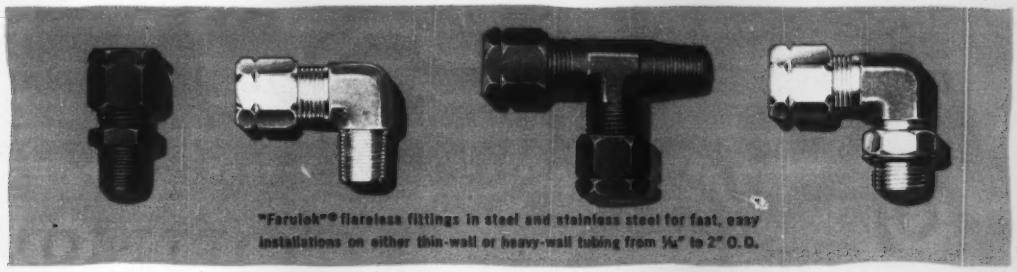
There are 2 standard models: The 2HCT-2, which is shown above at left, and the 2HCT-3, which is designed for noble metal couples, covering temperatures from 0 to 3,000°F in 3 steps. Setting to ½ part in 3,000 is accomplished with a direct reading digital dial.

For applications requiring reset and derivative control functions, the 2HCT is used with a Honeywell Three Mode Electr-O-Volt Controller. Write for 2HCT Specification Sheet to Minneapolis-Honeywell, Dept. **50**, Boston Division, 40 Life Street, Boston, Mass.

Honeywell

H HONEYWELL First in Control

For more information circle **54** on inquiry card.



"Ferulok"® flareless fittings in steel and stainless steel for fast, easy installations on either thin-wall or heavy-wall tubing from ¼" to 2" O.D.

Only from Parker

so complete a range of tube fittings for process and instrument lines

Select the proper tube fittings for any of your process or instrumentation lines from hundreds of different sizes, shapes and alloys in the Parker fittings line.

Parker "Intru-lok" fittings for fast, easy assembly of low- and medium-pressure lines in metal or plastic tubing. Fittings come ready to use without disassembly.

"Triple-lok" flare-type fittings make up leak proof on high pressure, high temperature lines. They are ASME-approved, ideal where safety is vital.

Leak-free, vibration-proof "Ferulok"® flareless, bite-type fittings hold pressure-tight on thin-wall or heavy-wall steel or stainless tubing. For semi-permanent joints on critical applications, use "Braze-lok" fittings on O.D. tubing. And use "Weld-lok" for highest temperatures and pressures.

Call your Parker fittings distributor for prompt delivery of Parker fittings from local stocks. He can also offer expert advice on any process or instrument tubing installation.

"Intru-lok" brass or aluminum flareless fittings for fast, easy installations on either plastic or metal tubing. (⅛" to 1" O.D.)

"Weld-lok" in steel and stainless steel for highest temperatures. "Braze-lok" in stainless steel, monel and Naval brass, silver-brazed for strength and reliability. (⅛" to 2" O.D.)

"Triple-lok" 37° flare-type fittings in brass, aluminum, stainless, and cadmium-plated steel for safe, trouble-free service. (⅛" to 2" O.D.)

Parker FITTINGS AND HOSE DIVISION

17325 Euclid Avenue • Cleveland 12, Ohio

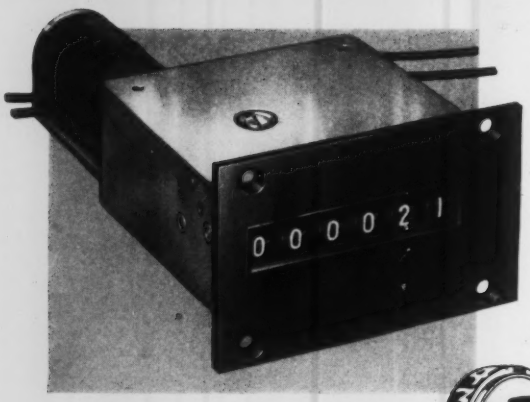
A DIVISION OF PARKER-HANNIFIN CORPORATION

For more information circle **55** on inquiry card.

How can you prove your guarantee unless your product can COUNT?

When customers come after you with claims concerning your product's performance, can you prove your position? You can, to everyone's satisfaction, if Veeder-Root Counters are built into your product as standard, integral parts. For then your customers have Facts-in-Figures on actual performance on the job, figures that settle arguments fairly and squarely . . . in fact, often prevent misunderstandings in the first place. What's more, when you build-in V-R Counters, you build up your product's sales appeal . . . as many manufacturers have found to their profit. So can you. Write and find out how.

You always "Know the score" when you count on Veeder-Root!



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book reviews

A Simplified Technique of Control System Engineering, by G. K. Tucker and D. M. Wills [1958]. Minneapolis-Honeywell Regulator Co., Brown Instruments Div., Wayne and Windrim Aves., Philadelphia 44, Pa., 303 + Xii pages, $5, 9¼" x 6", cloth. Provides graphical methods of understanding and improving process control starting with dynamic analysis by transient response, progressing to frequency response, analysis of a control system, and explaining an example of system-analysis and evaluation. Contains selected bibliography and terms.

Inverse Feedback, edited by Alexander Schure. [c 1956.] John F. Rider, New York 11, N. Y. 48 p., unbound. 90c. 8½ in. Explains principles and discusses typical applications.

Du Mont Industrial Cathode-ray Tubes. Ed. 2. [c 1956.] Allen B. Du Mont Laboratories, Passaic, N. J. 162 p., unbound. 9 in. Detailed specifications and circuit data for C-R tubes. Request on company letterhead.

Chemical Pilot Plant Practice, by Donald G. Jordan. [c 1955.] Interscience Publishers, New York 1, N. Y. 152 p. $3.50. 8¾ in. A very brief and simple treatment. Deals with general considerations, problems of "scale-up", handling and metering materials, pilot-scale reactors, and separation processes.

Electronic Semiconductors, by Eberhard Spinke, translates from German ed. 2 by D. A. Jeany and others. 1958. McGraw-Hill Book Co., New York 36, N. Y. 402 p. $11. 9¼ in. Rather rigorous introduction to physics of semiconductors.

Analytical Design of Linear Feedback Controls, by George C. Newton, Jr., Leonard A. Gould and James F. Kaiser. [1957.] John Wiley & Sons, New York 16, N. Y. 419 p. $12. 9¼ in. Treatment is necessarily highly mathematical.

Platinum Metals Review, quarterly. J. Bishop & Co., Platinum Works, Malvern, Penna., no charge—write to company direct. Contains six or more comprehensive articles on platinum technology, abstracts on current American and European literature on the platinum metals, and a section comprising abstracts of new patents pertinent to this field.

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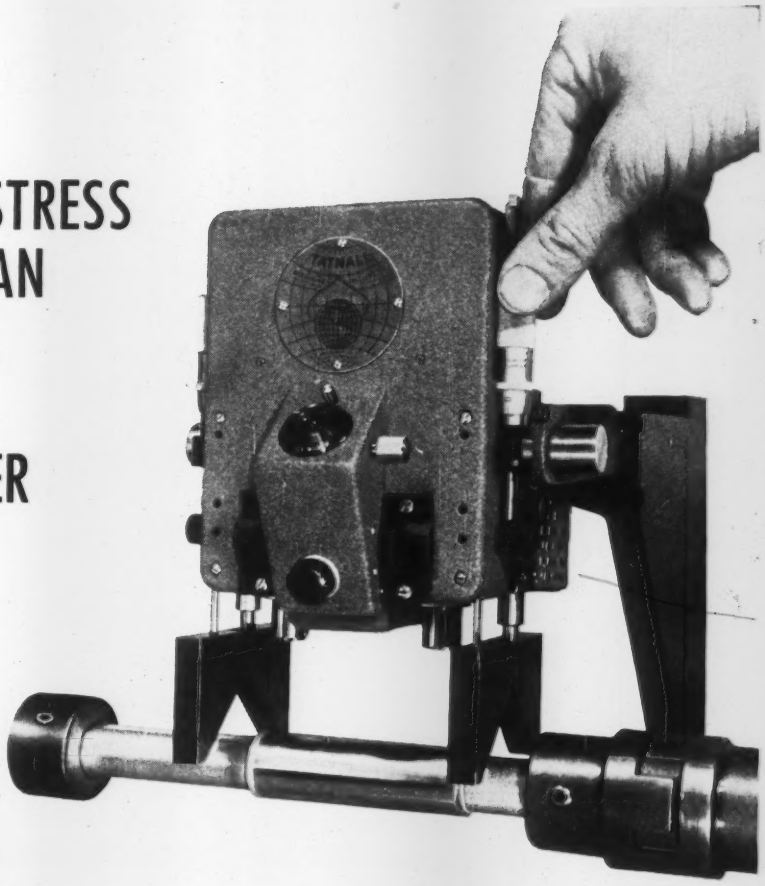

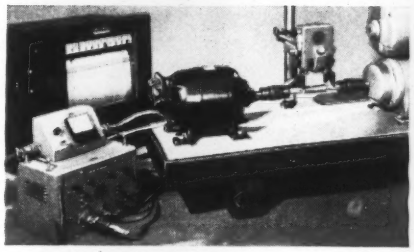

PhotoStress converts strain into color. The PhotoStress transducer converts color into electrical signals. Thus color patterns can be recorded accurately on oscillographs or other recorders or indicated on meters with no contact between the transducer and the part being measured.

The transducer is a servo-operated, null balance system consisting of two polarizing channels pointed at the torque shaft. A cylinder of PhotoStress plastic is bonded to the shaft, without cutting the shaft or without attaching slip rings. One channel looks at the active plastic, the other channel looks at reference plastic. The system compares the signals from the active and reference plastic, canceling out the effects of temperature and external light, photocell sensitivity, and power supply stability. The readout is digital and in millivolts for direct indication or recording. The accuracy is better than ¼% full scale, with long term stability 0.1% full scale and 1.5 microinch per inch strain accuracy. There is no speed limitation.

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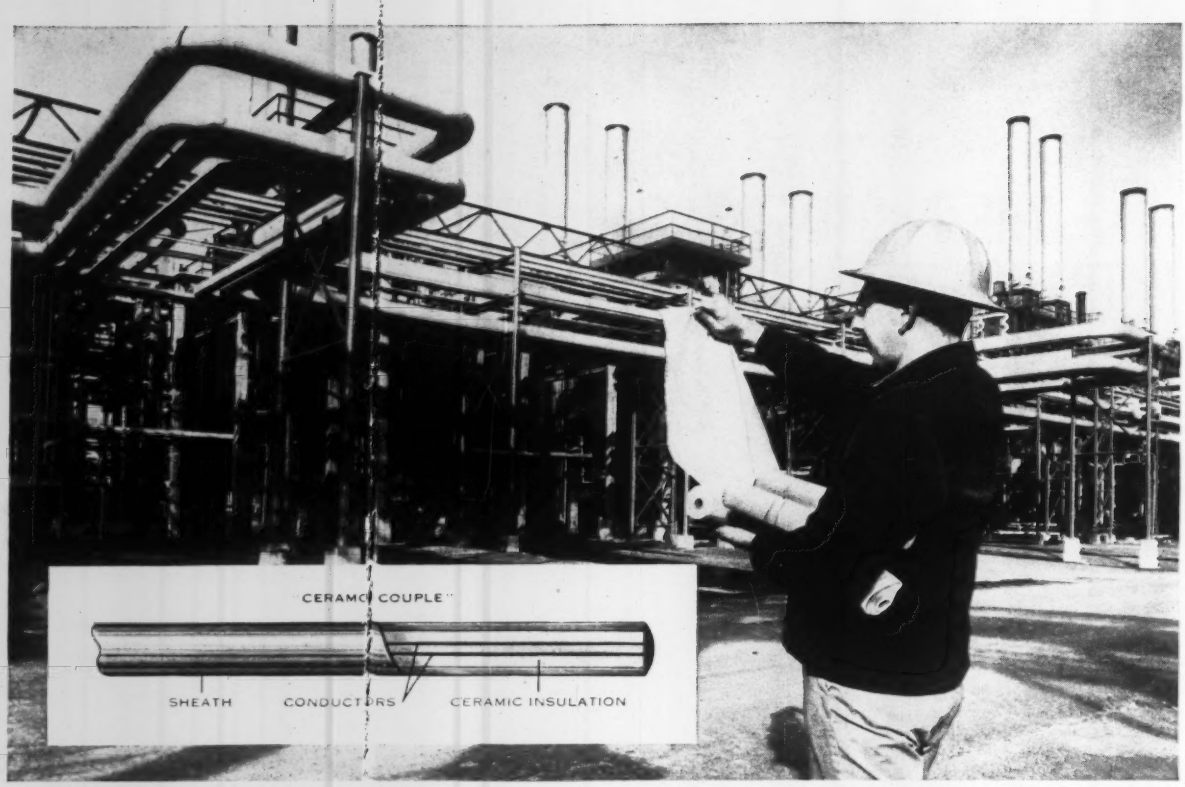

Process engineer at Sun Oil Refinery examining temperature measurements from "Ceramo" thermocouples.

Ceramo® Thermocouples Help Sun Oil Prevent Furnace Tube Failure

Thermo Electric's Versatile "Ceramo" Solves Another Problem

The Sun Oil Company refinery at Marcus Hook, Pa., found the answer to a difficult problem—preventing tube failure in their process heaters—with T-E's "Ceramo-Couples."

As coking and scaling build up within these tubes, heat transfer is reduced and tube temperatures rise. Unchecked, this condition can eventually result in costly, unscheduled shutdowns and potentially dangerous tube rupture.

Sun Oil also had another problem—rapid thermocouple failure. To measure tube skin temperatures from 500—1200° F. and withstand furnace temperatures to 1800° F., they were using 8-gage, insulated, pencil-type T/C's without protection tubes. Wires became brittle and soon broke. Hot junctions separated from the tube wall and read gas instead of tube temperatures. Process engineers had no confidence in readings. Costly, time-consuming installation of new T/C's was needed after every furnace shut-down.

Sun Oil went looking for a better thermocouple. They found it in T-E's "Ceramo"—ceramic insulated conductors encased in overall metal sheathing. Their 3/16" O. D. "Ceramo-Couples" have 20-gage Chromel-Alumel conductors and stainless steel sheathing. Thermocouple life was greatly increased, replacement was cut in half. Reliable readings from "Ceramo" permitted operation of process heaters at higher temperatures—thereby increasing production. "Ceramo's" ability to be bent on a small radius without shorting or grounding simplified installation. And "Ceramo" flexed with the differential motion between tubes and furnace walls.

Sun Oil now has about 300 "Ceramo-Couples" in use at Marcus Hook in 5 to 32 ft. lengths. During the 5 years "Ceramo" has been in use, Sun Oil has had no furnace tube failure or unscheduled shut-downs from faulty temperature measurement.

If you have problems of high temperature, moisture, abrasion, corrosion or difficult installation, investigate T-E's "Ceramo." Only "Ceramo" has the quality of materials and construction to meet all these needs.

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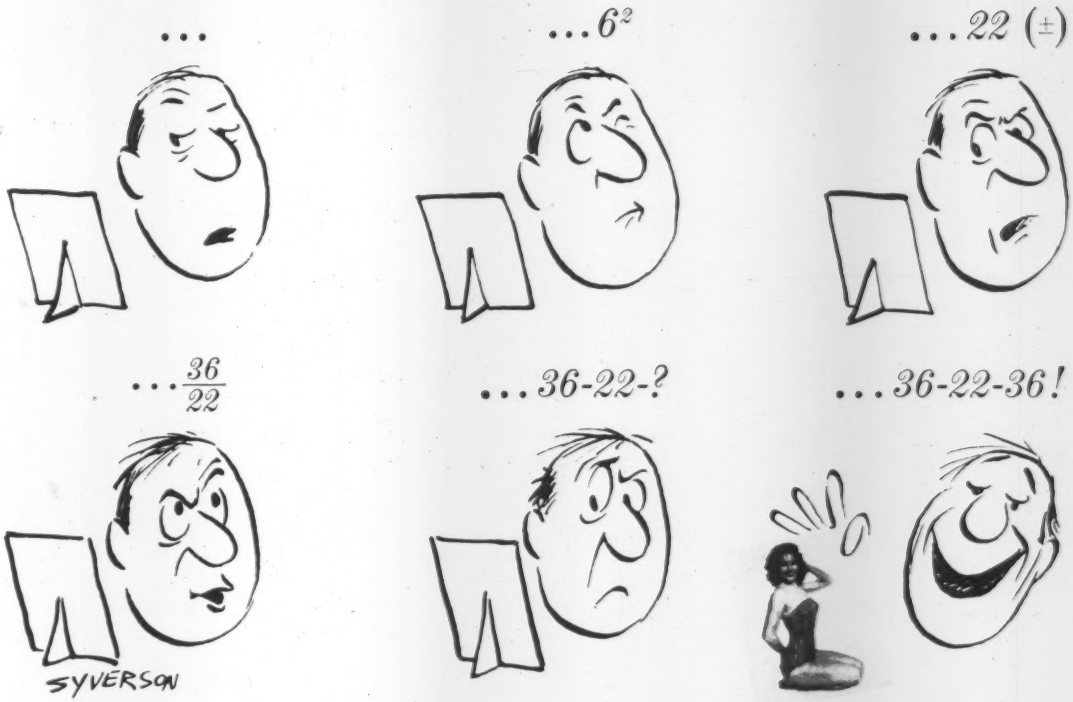

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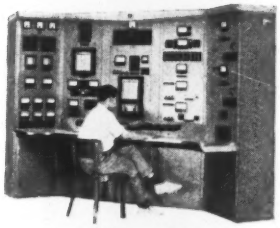

Here's another example of INET capability: the console, recorders and related instruments built, installed and wired by INET for Atomics International's L-54 nuclear research reactor. The solution-type L-54 reactor, which has a rated power capacity of 5,000 watts, was designed and built by Atomics International for the West Berlin Institute for Nuclear Research. It is being used for German scientific, medical and industrial research.

Engineers desiring a special reprint of the cartoon above should write to "36-22-36," c/o Inet Division, Leach Corporation.

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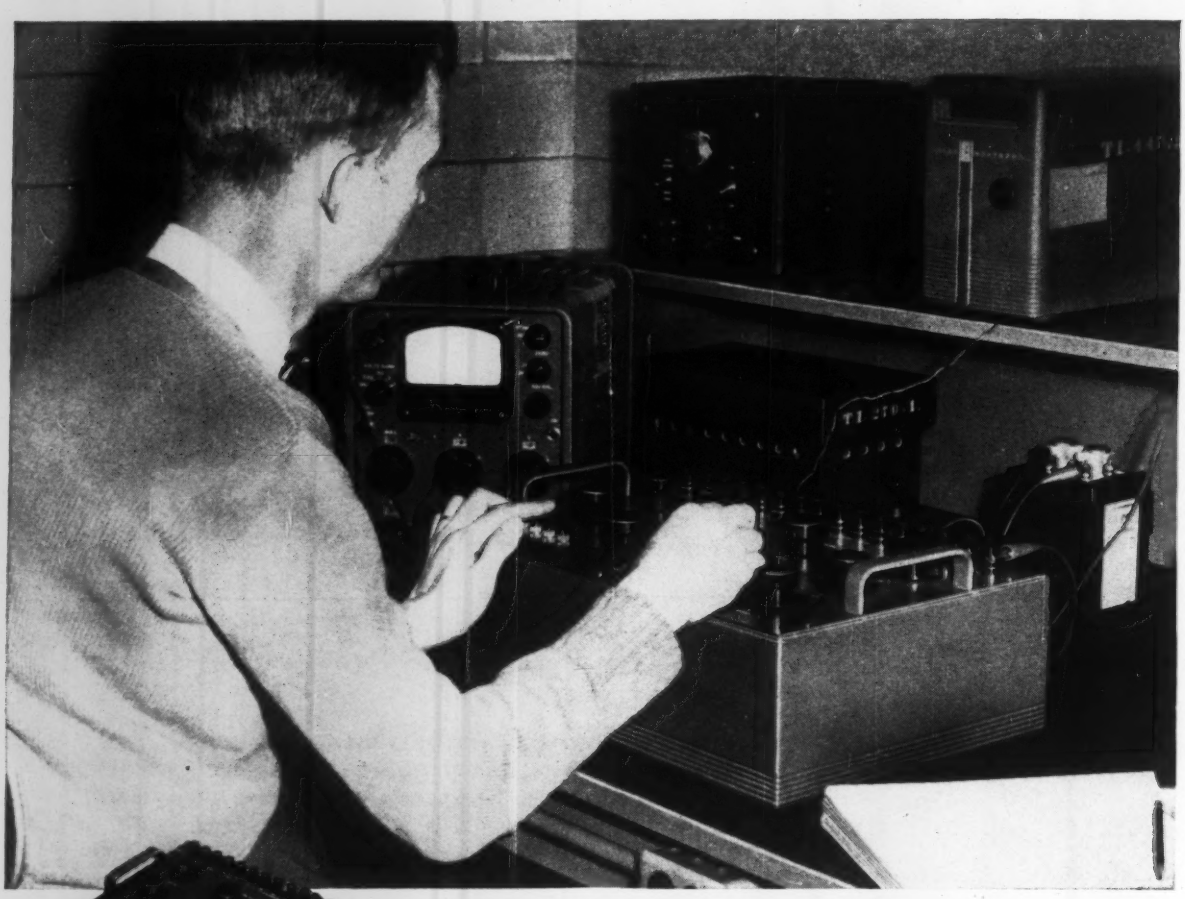

New Type K-3 Potentiometer keeps Melpar's radar test gear "on the beam"

Obtaining a high electrical accuracy is vital when designing and producing radar and fire control devices, analog and digital computers, etc. Melpar Inc. at Falls Church, Va., a subsidiary of Westinghouse Air Brake Co., relies on L&N's Type K-3 Universal Potentiometer as the prime d-c measuring instrument for their entire plant. The K-3 inter-compares standard cells calibrated by the National Bureau of Standards. Then, using these cells as reference, it calibrates the accuracy of voltmeters, ammeters and wattmeters used throughout the plant to check this complex electronic equipment.

This heavy workload of checking standards and instruments is easily handled by the K-3 because, as the head of the Quality Control Laboratory at Melpar says, its new design and convenience features permit "faster readings . . . and human errors are avoided because of the K-3's central reading window and decimal point indication of range. It is also much easier to standardize."

With these features, plus others such as the instrument's guarding against static and leakage, its built-in auxiliary potentiometer, etc., this Type K-3 will give you more accurate emf measurements in less time. Why not investigate the possibilities of this advanced potentiometer today. Write for the six-page Data Sheet E-51(6) on the K-3 from Leeds & Northrup Company, 4955 Stenton Ave., Philadelphia 44, Pa.

LEEDS Instruments **NORTHRUP** Automatic Controls • Furnaces

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editorial

Our Function and Field

IN 1928, the magazine *INSTRUMENTS—The Magazine of Measurements and Control*—began its long service to American instrument users and manufacturers. Its editor until his recent death, Major M. F. Behar, first used the word instrumentation in 1932 to cover the measurement and control systems aspects of the industry.

In 1954, the name was expanded to *INSTRUMENTS AND AUTOMATION* to emphasize the growing interest in the control aspects of instrumentation. Since 1954, the term "automation" has tended toward machine-tool and materials-handling control, which is but one phase of control.

Hence, beginning February, 1959, the name *INSTRUMENTS AND CONTROL SYSTEMS* will be a clear and unambiguous description of our function and editorial coverage. To emphasize this historical development, we begin in this issue a series entitled PROCESS CONTROL SYSTEMS, which will bring our readers scores of working control systems.

Report on Public High-School Course in Modern Engineering Physics

IN PITTSBURGH, PA., twenty-eight senior high-school students get up before 7 AM and hurry across the city to a central high school where, for 2 sessions per day, 5 days per week, they take a new type of physics curriculum. They spend the morning in this school, taking one other academic subject, and then return to their home schools for the afternoon.

Another group of 28 repeats the process in the afternoon, spending the morning in their home school and then hurrying (on their lunch hour) to the distant school, returning to their homes long after regular hours.

In order to take this class, each student assumes a burden of extra hours of academic instruction, plus the time required to travel to and from the school. Further, he must give up his study period and one other nonacademic subject to take a course which adds much homework to his considerable work load. The 2 class sessions, plus up to 2-hour transportation time, plus 1 or 2 hours of home work daily, add up to considerable volunteer effort.

What goes on at this school that has motivated these 56 students to volunteer for these many additional hours of schoolwork?

Let us look in on a typical class (see illustrations). There is an experienced high-school physics teacher and a modern electronics laboratory (an unusual but not extraordinary thing). The first unique things we see are many modern electrical, electronic, pneumatic, and hydraulic equipments of types not seen in high schools (or in many colleges either).

Then we see a lecturer. He is a specialist who has volunteered to cover his field of specialty—perhaps magnetics or pneumatic power supplies or infrared spectroscopy.

In front of the lecturer is an apparatus (magnetic amplifiers, a pneumatic filter, a spectroscope) which he uses to demonstrate the principles of his field.

The students have been prepared for the lecturer by the teacher, who covered the fundamentals of the field under study. The lecturer reviews the fundamentals, adds his experience, and demonstrates the equipment which he has brought into the lab, on loan from his company. The teacher reteaches where necessary and tests the students after the lecturer leaves.

We have here a combination of the best teaching practice of many fields old and new—an experienced teacher, an organized curriculum, expert authorities in modern technologies, plus the most modern apparatus. The combination has been sufficiently motivating to have these students assume as much as 6 hours *additional* work per day, and love it. Neither a public transportation strike nor an epidemic, both of which cut into attendance at conventional classes, reduced the attendance at this class. We shall see what the students, teacher, school authorities, and lecturers have to say about this course.

This cooperative program between the technical community and the public school authorities of Pittsburgh has resulted in a new type of physics course. Although developed under the name of "automation," the course is best described as *Modern Engineering Physics* because it evolved into a course in industrial physics, emphasizing instrumentation and electronics.

This report will survey (1) the concept, (2) the plan, (3) the chronology of events, (4) the final curriculum, and (5) results to date.

The Concept

The concept, background and approach are described here because they represent a proved method by which any industrial community can help its public school system to upgrade and modernize a phase of its technical education function.

The first step was the formation in July, 1956, of a committee of local scientists and engineers (see Appendix 1) representing different phases of industry

Edmund Winstel of the Bristol Co. lectures on pneumatic controllers, using a Dynamaster potentiometer recorder-controller.

John Douglas of Minneapolis-Honeywell lectures on high-speed recorders, including Visicorders.

Dr. Axel Peterson of Mellon Institute of Industrial Research (now with Boeing Aircraft) lectures on x-y recorders, using a Moseley recorder to demonstrate principles and practice.

Walter Stancati of The Foxboro Co. lectures on pneumatic controllers, using modern Dynalog equipment.

Dr. Ralph Ely of Nuclear Science and Engineering Corp., lectures on Nuclear Instrumentation, using scalers, counters, and detectors.

and science in the Pittsburgh area—steel, research laboratories, radio stations, chemicals, etc. Note: This was before Sputnik!

At early meetings the committee members had different ideas of what was needed, but they agreed after discussion that there was a ground common to all their fields which was not covered adequately in existing curricula. This common ground included ELECTRONICS and MEASUREMENT AND CONTROL INSTRUMENTATION, with emphasis on theory *and* modern apparatus.

A rough curriculum, agreed upon by the committee, revealed that many subjects were included that were alien to a conventional physics curriculum. These subjects included digital techniques (digital circuits and arithmetic), servomechanism fundamentals, pneumatic circuits, recording potentiometers, etc. It became evident that no one teacher could teach these diverse subjects, all of which, although essential to modern industrial physics, were too new to be parts of conventional physics curricula. It was also agreed that these new technologies could be best taught if some hardware could be shown and used to illustrate how the scientific principles were put to use.

The committee decided that a way to cover these areas of modern technology and to obtain equipment would be via help from local technical societies in each technical field. It was planned to ask each of the local chapters of thirty technical societies in the Pittsburgh area to assume the responsibility for its phase of the course. This responsibility would entail (1) assisting and guiding the teacher in curriculum details, (2) providing visiting lecturer-experts, and (3) arranging for demonstrations of modern apparatus.

Fourteen societies (Table 1) eventually assisted in the course either with technical or financial help. Without them the course would not have been possible.

The final curriculum that evolved from this year-long effort by scores of engineers and scientists in the Pittsburgh area, working with the school system, is shown in Table 2. It is the actual curriculum covered —*not just a plan*. More than 100 scientists and engineers cooperated in the project, either as organizers of the various phases or as lecturers; more than $250,000 worth of modern scientific apparatus was used in

TABLE 1—COOPERATING SOCIETIES

1. American Chemical Society, Pittsburgh Section
2. American Material Handling Society, Pittsburgh Section
3. American Nuclear Society, Pittsburgh Section
4. American Society for Metals, Pittsburgh Section
5. American Society for Quality Control, Pittsburgh Section
6. Association of Iron and Steel Engineers, Pittsburgh
7. Illuminating Engineering Society, Pittsburgh Section
8. Institute of Radio Engineers, Pittsburgh Section
9. Instrument Society of America, Pittsburgh Section
10. National Association of Corrosion Engineers, Pittsburgh Section
11. National Machine Accountants Association, Pittsburgh Section
12. Society for Nondestructive Testing, Pittsburgh Section
13. Spectroscopy Society of Pittsburgh
14. Standard Engineers Society, Pittsburgh Section

TABLE 2—FINAL CURRICULUM IN MODERN ENGINEERING PHYSICS

INTRODUCTION
- Standards
- Units of Measurements

ELECTRICITY
- Nature of matter
  - Electrons
  - Ions
  - Direct Current
  - Alternating Current
- Resistance, capacitance and inductance
- Impedance and resonance
- Signals and simple R-C-L circuits
- Time constants
- Basic movements
- Standards instruments
  - D'Arsonval movements
  - Potentiometers
  - Electrodynamometers

MAGNETISM
- Magnetic fields
- Magnetic materials and properties
- Hysteresis loops
- Gaussmeters*
- Magnetic amplifiers

ELECTRONICS
- Vacuum tubes
- Gas tubes
- Amplification
- Oscillation
- Rectification
- Power Supplies
- Solid state amplifiers
- Transistors, magnetic amplifiers, static switches
- Modulation and demodulation
- Limiters and signal shaping circuits
- Electrical and electronic test equipment
  - Voltmeters
  - Ohmmeters
  - Ammeters
  - Volt-ohmmeters
  - Vacuum-tube voltmeters
  - Signal generators
  - Oscilloscopes
- Communication and television circuits
- Military electronics
- Communications receivers
- Transmitters
- Radar*

MECHANICS
- Displacement measurement*
- Velocity measurement
- Acceleration measurement
- Introduction to first and second-order derivatives

INDUSTRIAL MEASUREMENT AND CONTROL
- Indicators and basic movements
- Recorders
  - Direct deflection galvanometers
  - Self-balancing potentiometers
  - X-Y recorders
  - Strip-chart recorders
  - Heat-sensitive recorders
  - Electrosensitive recorders
  - Operations recorders
- Controllers and servomechanisms
- Pneumatic controllers
- Hydraulic controllers
- Electric controllers
- Electronic controllers
- Feedback theory
- Pressure and force
  - Bourdon gages
  - Load cells
  - Diaphragm gages
  - Manometers
  - Strain gage instrumentation
  - Weighing techniques
- Temperature
  - Thermocouples
  - Infrared
  - Filled systems
  - Thermistors
  - Resistance thermometers
  - Optical pyrometers
- Flow
  - Differential-pressure techniques
  - Turbine types
  - Positive displacement
  - Ultrasonic techniques
- Humidity
- Electrochemical analysis
  - pH
  - Emission spectroscopy
  - Infrared spectroscopy
  - Mass spectroscopy
  - X-ray diffraction
  - Ultraviolet spectroscopy
  - Chromatography
  - Titrimetry
  - Spectrophotometry
  - Oxidation-reduction
  - Metallurgy of iron and steel
  - Metallurgy of light metals
- Nondestructive testing
  - Radiography
  - Magnaflux
  - Ultrasonic inspection
  - Eddy current technique
- Acoustics
  - Sound measurement*
- Optics
  - Light measurement*
- Quality control
  - Statistical analysis
  - Sampling
  - Probability theory
  - Dimensional gaging and inspection
- Modern materials handling

NUCLEAR PHYSICS
- Introduction to nuclear physics
- Mass-energy transformation
- Nuclear detectors for alpha, beta, gamma, and neutrons
- Reactor fundamentals and reactor control
- Health physics

COMPUTING AND DATA ANALYSIS
- Binary mathematics
- Codes
- Programming a computer
- Matrix and logic elements
- Solution of simple differential equation by analog computer techniques*
- Mathematical tools and aids

*Subjects marked by asterisks were not covered thoroughly in the first year's program, but will be in the second year's program.

the program. Table 3 lists the lectures and demonstrations presented to the class; the illustrations show typical classes.

The method by which each society approached its subject is shown by the programs designed by two societies—the SSP and SNDT (Appendixes 6 and 7).

Results of Course

The subject matter and teaching approach have been described. The 56 students who took this year-long course graduated in June of 1957 and 41 are now in college. Two students went directly into family-type businesses; five others went into the armed services. Several were available for technicians' positions, and several firms in the area wanted high-school graduates with backgrounds of this type.

The impact of the course may be gleaned from the reactions of those closest to the course—(1) teacher, (2) students, (3) lecturers, (4) school system.

Teacher Reaction

In evaluating the teacher reaction, let it be noted that Mr. Ned Replogle has taught physics for 35 years and is one of the most highly regarded physics teachers in the Pittsburgh public-school system. He says:

"After teaching physics for 35 years, I feel that I have only now discovered Modern Physics. This is physics in its finest sense, the theoretical-practical sense. I could not go back to conventional physics teaching after this stimulating course, and am postponing my retirement to teach this course.

"I have served on two course of study committees. One committee wrote the regular course of study now in use, the other a proposed advanced course. Plans for improving our science program include an accelerated and more inclusive basic course for the gifted students, followed by another year of advanced physics. It would be difficult to design a course that would function better for this advanced course than the present automation course.

"The cooperation of the industrial societies in bringing in the latest developments in their areas, keep the

TABLE 3—LECTURES & DEMONSTRATIONS PRESENTED TO CLASS BY COOPERATING SOCIETIES

SUBJECT	LECTURER AND SOCIETY AFFILIATION	COMPANY
Basic Instrumentation and Recorders		
1. Introduction to course	M Aronson (ISA-IRE)	Instruments Publishing Co.
2. Introduction to instruments	Dr. A. Peterson (ISA)	Mellon Institute
3. Indicating and recording instruments	Edmund Winstel (ISA)	The Bristol Co.
4. Potentiometer recorders	Walter Stancati (ISA)	Foxboro Company
5. Ring balance recorders	G. W. Wolf (ISA)	Hagan Corp.
6. High speed recorders	John Douglas (ISA)	Minneapolis-Honeywell
7. Solar battery	Mr. H. A. Byron	Bell Telephone Co.
Chemical, Analytical, Metallurgical		
8. Spectroscopic analysis	J. Paterson (SSP)	Jones and Laughlin
9. X-ray diffraction	R. K. Scott (SSP)	Harbison-Walker
10. Infrared spectroscopy	Harold Lady (SSP)	Westinghouse Research
11. Mass spectroscopy	Janet Schultz (SSP)	Bureau of Mines
12. Gas chromatography	Dr. D. L. Pettijean (ACS)	Alcoa
13. Spectrophotometry	L. Hartley (ACS)	U. S. Steel
14. p-H and Titrimetry	J. Edward Kolter, Jr. (ACS)	Fisher Scientific
15. Metallurgy of iron & steel	R. Lindsay (ASM)	Crucible Steel
16. Metallurgy of iron & steel	O. E. Romig (ASM)	U. S. Steel Corp.
17. Metallurgy of iron & steel	F. Dlugonski (ASM)	U. S. Steel Corp.
18. Metallurgy of light metals	W. Freeman (ASM)	Alcoa
Magnetics		
19. Static switches and magnetic amplifiers	Roy Clark	Westinghouse
20. Static switch and magnetic amplifiers	Paul Hanna	Westinghouse
Nucleonics		
21. Introduction to Nuclear Physics	Dr. A. F. Henry (ANS)	Westinghouse-Bettis
22. Nuclear instrumentation	Dr. Ralph Ely (ANS)	Nuclear Science and Engineering Corp.
23. Reactor control	N. E. Wilson (ANS)	Westinghouse-Bettis
24. Biological aspects	Prof. H. Cember (ANS)	University of Pgh.
Testing		
25. Radiography	I. Modl (SNDT)	Alcoa
26. Magnaflux testing	I. W. Horton (SNDT)	Magnaflux Corp.
27. Ultrasonic testing	E. Graboski (SNDT)	US Steel Corp.
28. Eddy current testing	D. Kunkle (SNDT)	Alcoa
Industrial Measurement & Control		
29. Humidity instruments	Walter Stancati (ISA)	Foxboro Co.
30. Pneumatic fundamentals	P. Hankison (ISA)	Hankison Corp.
31. Air supplies	D. Bice (ISA)	Hankison Corp.
32. Electronic controllers	L. P. Lumpkin (ISA)	The Bristol Co.
33. Pneumatic controllers	Walter Stancati (ISA)	Foxboro Co.
34. Pneumatic controllers	H. Sturak (ISA)	Foxboro Co.
35. Pneumatic controllers	P. McQuillan (ISA)	Moore Products Co.
36. Flow meters	D. H. Krause (ISA)	Fischer-Porter Co.
37. Steel-mill weigher-inspector-marker	A. Phillips	Loewy-Hydropress
38. Strain-gage instrumentation	W. Murray	MIT
Digital Techniques		
39. IBM 650 principles Univac Demonstration	Fred Dexter (NMAA)	Hospital Service Association Remington-Rand
40. IBM 650 demonstration	David Bell (NMAA)	Jones and Laughlin
41. IBM (Program)		Mellon National Bank
42. One week class lectures on programming IBM 650	Miss Marsha McGoey (NMAA) (Educational Department under George Mosley)	IBM
43. Electronics and mechanics of IBM machines	Walter Nenza (NMAA)	IBM
Quality Control		
44. Quality Control	Frank Kaplan, Jr. (ASQC)	Westinghouse Electric Corp.
45. Gauge accuracy	David H. Hunter (ASQC)	Hunter Gauge
46. Theory and practice of statistical quality control	John D. Hromi (ASQC)	U. S. Steel Corp.
47. Control chart for variables	Ralph A. Maggio (ASQC)	Jones and Laughlin
48. Attribute control charts	Frank Kaplan, Jr. (ASQC)	Westinghouse Electric
49. Sampling plans	Lawrence F. Jones (ASQC)	Westinghouse Electric
50. Tests of significance	Wm. P. Goepfert (ASQC)	Aluminum Co. of America
51. Regression and correlation	George Shombert, Jr. (ASQC)	Allis-Chalmers Mfg. Co.

course modern and up to date, at the same time giving the student a basis for choosing a field of engineering. The mutual acquaintance is beneficial to both students and the lecturers."

These comments show the impact that modern physics technology can have on an experienced and respected physics teacher. These comments should be reread by anybody who feels that this course is "vocational" or designed only for technicians!

Student Reaction

The students were asked to give frank opinions of the value of their considerable extra effort. Here are a few typical comments:

"I think this course will stand as one of the greatest experiences I have or will have experienced in my lifetime. The course made Physics elementary in comparison. The *Electronic Circuitry* book is a student's Bible."—*Henry Wong.*

"In one year of automation I have gained more than in my other 3 years of high school. The course has helped me in all my other grades. In Physics classes we just fringe on subjects that we cover thoroughly in this class. It seems odd in my Physics classes when I see that I have a much better understanding of electronics and so on than the rest of the students in the class. Of all the books I have studied in here, I thought the *Digital Techniques* was best."—*Bill Bealles.*

"The course in automation has given me a background of scientific principles that should help me in the future. The electronics part of the course supplied me with knowledge of a subject that was totally unfamiliar to me previously. The physics, chemistry and other related subjects offered as a part of the course expanded and clarified the regular subjects I had in high school, and added many more that I wouldn't have had. Overall, I feel that this course is perhaps the most valuable preparation that I could have had in preparation for my future career."—*Lew Snizik.*

"This course is the best thing that ever came into my education. It has stimulated my interest in my other technical subjects in high school."—*Edward Stewart.*

"I have gained many valuable concepts I could not have gotten elsewhere. No doubt at sometime in the future it will become even more important than I now realize. I think the course accomplished its purpose, that is, to teach fundamentals through practical applications, and I have advised several of the juniors at my own high school to take it if the opportunity arises. This course has rather definitely determined my course of college study. I will enter Carnegie Tech in the fall and enter chemical engineering, later to go into spectroscopy and metallurgy."—*Bill Garland.*

The important facts that emerge from these comments include: (1) The course *strengthened* and supplemented existing physics and chemistry curricula. IT WAS NOT A SUBSTITUTE FOR, BUT AN ADDITION TO, EXISTING PHYSICS AND CHEMISTRY CURRICULA. (2) It surveyed many fields. How many students entering technical colleges know anything of metallurgy, spectroscopy, nondestructive testing, nucleonics, instrumentation, etc? These were not only surveyed in this course, but covered in principle *and* practice.

Physics is a horizontal subject that embraces many different fields. The senior high-school level is the perfect level at which to teach and survey these fields in this manner.

Reactions of Lecturers

The lecturers were industrial and scientific workers in responsible positions, all authorities in their fields. Here are some reactions from these men:

"The American Nuclear Society was happy to have participated in the presentation of this course, and is pleased with the response of the students involved."—*W. H. Esselman, Westinghouse Electric Corp., Bettis Atomic Power Division.*

"The Spectroscopy Society is proud to be a part of such a worthwhile undertaking . . . You will continue to receive our support."—*Gerald L. Kearns, Pittsburgh 30, Pa.*

"I was amazed at the level of the theory and practical work in which these students are engaged. It almost parallels the procedures followed in industry, insofar as both the courses being taught and the hardware used is concerned."—*E. A. Eisler, Industrial Service Div., Minneapolis-Honeywell Regulator Company.*

"I have had the opportunity of giving three classes at this course, two covering electronic instrumentation and one on pneumatic instrumentation . . . In my opinion, the students are in a class by themselves. They are some of the most alert and intelligent young men I have had the privilege of meeting . . . *The theory of electronics taught is as deep in scope as that encountered by students at least during the first two years of college.* The pneumatic instrumentation and the coverage of basic measuring systems give an excellent foundation for an understanding of all types of instrumentation. At the same time, giving the students actual working experience on the different types of instruments furthers the understanding of the theory previously taught. This course should be of great value to any student entering the field of engineering."— *L. P. Lumpkin, District Manager, the Bristol Co.*

"I was gratified to discover that these high-school students were well grounded in both the fundamentals of electricity and electronics, and its practice in modern instrumentation. They displayed an awareness of principles and practice that I would not have expected in a high-school student. This course should be invaluable preparation for any student entering any technical field at any level, and should prepare them to handle the toughest technical university. I found the experience of lecturing to them extremely rewarding. Nothing I said that was vague went unchallenged. These students should go far in college."—*Walter Stancati, The Foxboro Company.*

Reactions of School Officials

Statement by Superintendent

"The administrative personnel of the Pittsburgh Public Schools interested in the advancement of physics in the public schools, appreciate the strong cooperation binding industries, technical societies, and labor with our schools. The Committee of Consultants from these groups collaborated in the organization and realization of our course in automation, better known locally as Modern Engineering Physics."—*Dr. Calvin E. Gross, Superintendent, Pittsburgh Public Schools.*

Statement by Senior Supervisor, Science & Mathematics

"The automation program fills a need long felt but seldom recognized in the academic secondary education area.

"The areas of science and mathematics have built their separate structures as if their independence were a desirable feature. They have remained verbal and abstract to a degree that implies that the concrete and practical are not equally contributive to culture. They have offered opportunity only to the peculiarly able in the abstract and verbal; a fragile web that is a ladder to a few but which enmeshes very substantial people with other capabilities.

"The automation program offers not only equal possibilities in the realm of the abstract, but problems, real materials and action to a conclusion in the concrete. The tragedy of science—'when a beautiful theory meets an ugly fact,' with the death of an idea—becomes in automation the destruction of equipment and possible danger or injury. There is no training experience so effective as that under *live* ammunition.

"Any major area of secondary school experience must be equally a citizenship-character training experience. In automation again the experience goes beyond the realm of ideals and ideas into the habits and practices in relation to community responsibility for real materials.

"The automation program has within its scope the possibilities of relating math and science, giving them expression for real experiences for able students whatever the direction of their unusual abilities, and doing it in an environment of real and practical life experience. It may be truly a cultural experience."—*Eugene F. Peckman, Senior Supervisor, Science & Mathematics, Pitttsburgh Public Schools.*

Statement by Director of Vocational & Industrial Arts Section

"This new physics course, one of enrichment, has been highly successful. Its strongest and best contribution lies in areas of high motivation and in giving the students an opportunity to learn at first-hand the principles involved and the functioning of many and varied types of the latest instruments. This course offers many rare opportunities to these students who are primarily scientists and engineers in the making.

Electronics is the one subject that is emphasized throughout the course and gives cohesiveness to the entire concept. Instruments valued at about a quarter of a million dollars is another reality and concept that is noteworthy. It would seem to me that all physics departments could well profit by some or all phases of this project."—*Charles F. Hoffmaster, Director, Section on Vocational & Industrial Arts Education.*

The Future

It is hoped to spread the modernizing influence of this physics curriculum by the following techniques:

1. Each society is being asked to prepare its presentation in booklet or monograph form. This, plus a display manifold, might permit the teacher to do the job without the cooperating expert. after the teacher has learned the field in question.

2. It is hoped to give this course as a night-school course to math-science teachers within the school system next year. As an honorarium of $200 should be given to any teacher who volunteers for a full-year night-school course, funds in the amount of $4000 are being sought to accomodate 20 teachers.

3. It is hoped to give the same course next year with greater emphasis on the equipment and less emphasis on the theory, to a technician-type group in a vocational school. Not one student was available from this course for a technicians job.

4. The lecture-demonstrations could be filmed. This is being investigated.

Some of these ideas could have been realized last year if any support could have been found within the many foundations said to be interested in instrument education.

Conclusion

Each phase of the curriculum given in Table 2 was delivered with power both by experts in the field *and* by a professional teacher. It was a full-year course emphasizing fundamentals.

The outline represents the physical world today; it represents the fields where scientists and engineers work and the equipments with which they work. This curriculum is Modern Engineering Physics; it encompasses every phase of physics; it complements and supplements the regular physics and chemistry courses —it is NOT suggested as a substitute.

The curriculum has found opposition from certain groups. This opposition has been found to be based on an "anti-hardware" teaching premise which originates at the university level, but which is a threat to education at all levels and to the nation. As it poses a direct threat to the instrument industry it will be discussed in detail in the March issue of *Instruments & Control Systems.*

Special credit is due the officials of the school system who worked with dedication and foresight in planning this program. These men are:

Dr. Earl A. Dimmick, Superintendent of Schools (now retired).

Dr. Evan W. Ingram, First Associate Superintendent

Eugene Peckman, Senior Supervisor, Science and Mathematics

Charles F. Hoffmaster, Director of Vocational and Industrial Arts Education

Dr. John P. Schaefer, Director of Personnel

Oscar J. Schwarm, Director of Guidance and Child Accounting

Thomas Pryde, Senior Area Coordinator, Trade and Industrial Education, Department of Public Instruction

Harold B. Black, Assistant Director, Vocational and Industrial Arts Education

John H. Kudlik, Supervisor, Vocational and Industrial Arts Education

Note that both academic and vocational groups cooperated to produce this new type of academic course. The chairman of the committee of consultants wishes to go on record as saying that never in his experience has he seen executives cooperate so selflessly in a program that cut across all established lines of authority. The men listed above are "big" in the best figurative definition of that word.

Appendix 1—Committee of Consultants to the Pittsburgh Board of Education on Instrument/Automation Education

Milton H. Aronson, Chairman, Editor, Instruments and Control Systems

Axel H. Peterson, Co-Chairman, Head, Department of Instrumentation, Mellon Institute of Industrial Research (now with Boeing Aircraft)

Dominic Dornetto, Int'l Representative, UAW-CIO.

Leslie R. Driskell, Principal Instrument Engineer, Blaw-Knox Company, Chemical Plants Division

J. A. Fink, W. S. Hill Co.

James H. Greenwood, Chief Engineer WCAE, Inc.

George Karnofsky, Staff Associate, Blaw-Knox Company, Development & Research Dept.

James Kelley, Instrument Engineer, American Cyanamid Co.

T. C. Kenney, Chief Engineer, Westinghouse Radio Station-KDKA

Ernest O. Ohsol, Director, Res. & Devel., Pittsburgh Coke & Chemical Company

D. Maxwell Seeley, Ass't to V. P. Appropriations, U. S. Steel Corp.

J. Senyk, Head, Instrument Section, Engineering, Engineering Division, Mfg. Department, Gulf Oil Corp.

G. W. Walther, Mgr., Chem. Production, Pittsburgh Coke & Chemical Company

Appendix 2—Equipments Donated to Course

Cutaway valve, pneumatic controller, liquid level controller, model of cutaway diaphragm control valve—Fisher Governor Co. (via local representative, J. G. Chilcoat Co.)

Conductivity bridge and cells—Kurt Lesker Company (representing Industrial Instruments, Inc.

Plastic model of diaphragm-controlled jet pipe regulator—Askania Regulator Co.

Brooks rotameter—Brooks Rotameter Co.

0-300 lb. pressure indicator—Crosby Valve and Gage Co.

Six voltmeters, dc and ac—Instruments Publishing Co.

Bronze relief valve—Tanner and Arnold

Complete tank gaging system, including petrometer, compressor, tubing, etc.—Petrometer Corp.

Capacitrol temperature control system—Barber Colman Co., Wheelco Instrument Division

Air filter—Hankison Corp.

Flowrator flow meter—Fischer & Porter Company

Simplytrol automatic pyrometer—Assembly Products Co.

Contact meter relays (10)—Assembly Products Co.

Explosimeter analyzer—Mine Safety Appliance Co.

Sulphide detector—Mine Safety Appliance Co.

Process pilot-type controller—Black, Sivalls and Bryson Co.

Pressure regulator—White Industrial Sales

Electronic Remote Controller—Fenwal Inc.

Thermistor Probe—Fenwal Inc.

Power Supply—Fenwal Inc.

Wind meter—Dwyer Instrument Co. (via local representative, Sentinel Products Co.)

Safety Valve—The Bristol Co.

Low pressure indicator—Dwyer Manufacturing Company

Precision valve—Research Controls

Plastic tubings and fittings—Sam Moore and Company

Appendix 3—Financial Donors to Course

American Materials Handling Society, Inc., Pittsburgh Chapter

American Society for Quality Control, Pittsburgh Section

Association of Iron and Steel Engineers

Blaw-Knox Company

J. G. Chilcoat and Company, Inc.

Instrument Society of America, Pittsburgh Section

Instruments Publishing Company

M. S. Jacobs and Associates, Inc.

Jones and Laughlin Steel Corporation

Pittsburgh Coke and Chemical Company

Rockwell Charitable Trust

The Alcoa Foundation

United States Steel Corporation

Total collected—$5950

Donations ranged in size from $25 to $1500

Appendix 4—Chronology of Basic Steps

July, 1956—Formed Committee of men holding top technical jobs in the basic industries of this area. Men of various societies were included. A representative of labor also was included.

August, 1956—Committee agreed that electronics, instrumentation and automation are basic to almost all industrial and scientific work, and prepared outline of major topics that should be included in a modern course of industrial physics.

September, 1956—Working with school officials, committee found that senior high-school students had two hours per day that were available for an *additional* course, one hour now being devoted to study period, and one to music, gym, or other non-academic subject.

October, November, December, 1956—Worked out course content, calculated budget, contacted technical societies for financial and technical assistance.

February, 1957—Made proposal to school board, giving objectives and course content. Board approved plan and allocated $27,000 of needed $47,000 budget. Remainder to be raised by the committee. Actual proposal was published in *Instruments and Automation*, Feb., 1957, p. 237-239.

March, 1957—Leaflets (76,000) were included with report cards, telling parents and students of plans for course. See *Instruments and Automation*, May, 1957, p. 870.

April, 1957—One-half hour program on TV Channel 2 explains course to Pittsburgh TV viewers.

May, 1957—High schools were visited by committee members to select one with best facilities for the course. School with central location was selected because students would travel to this school for one half day, every day, and then return to "home" school.

June, 1957—Of 400 applicants for course, 56 were selected on basis of aptitude tests given by school officials.

July, 1957—Interviewed teacher prospects. Selected an accredited, experienced high-school physics teacher who had mechanical and electronic aptitudes.

August, 1957—Sent teacher to instrument-manufacturer school for indoctrination to modern instrumentation. Worked with teacher on text material.

September, 1957—Class started, with 56 pupils, one teacher, one laboratory assistant; 28 students in morning class; 28 in afternoon class.

As only $5950 of the desired additional $20,000 was raised—all from local sources—budget was pruned of technical aids, itinerant teacher, and about one half of desired supplies. This cutback did *not* interfere with the course progress. Every cent raised was raised locally. The job has been done with no outside financial help, other than equipment loans and donations from instrument manufacturers.

Appendix 5—Texts and References Used

Basic electronics text used throughout course was *ELECTRONIC CIRCUITRY FOR INSTRUMENTS & EQUIPMENT*, by M. H. Aronson, Instruments Publishing Co., Pittsburgh 12, Pa. $2.00. (Teacher comment: "This text is the best book that I could find for this purpose at this level.")

Basic text used for digital arithmetic and computers was *DIGITAL TECHNIQUES FOR COMPUTATION & CONTROL*, Klein, Morgan & Aronson, Instruments Publishing Co., $6.00 (Teachers comment: "Digital book offers both principles and exercises for constructing computer circuits. It clearly explains binary math and its application in computers.")

Process instrumentation was covered by service Manuals and Bulletins donated and used as supplementary texts:

Conversion Tables for Thermocouples—Minneapolis-Honeywell

Fundamentals of Industrial Controls—Minneapolis-Honeywell

Pneumatic Control—Minneapolis-Honeywell

Thermoelectric Thermometry by Paul H. Dike, Leeds & Northrup Co.

Instrument Diagrams with Notes—Foxboro

IBM-650 *Data Processing System Manual of Operation*—International Business Machines

pH Manual—Beckman Instruments

Each student had a personal subscription to *INSTRUMENTS & AUTOMATION* for one year. He also received, as a bonus with the subscription, the book *HANDBOOK OF MEASUREMENT & CONTROL*, edited by M. F. Behar, Instruments Publishing Co., which was used for thermometry, pyrometry and other subjects.

The following books resulted from the first year's work in this course, and will be available for the second year:

STRAIN GAGE INSTRUMENTATION, Aronson & Nelson, Instruments Publishing Co., $2.00

RECORDERS, Aronson & Nelson, Instruments Publishing Co., $2.00

Teacher comment: "The students studied the monthly issues of trade journal *INSTRUMENTS & AUTOMATION*, which covered the following subjects adequately—strain gages, recorders, nucleonics. This trade journal is surprisingly educational in its approach to basic physics and measurements. Educators should take notice of its unusual educational approach; many issues can function as a text in a given field of measurement or control."

Appendix 6
Phase of Program Designed by Society for Nondestructive Testing

The SNDT covered the following subject matter:

Radiography
- History
- Generation of X-rays
- Types of equipments
- Geometrical considerations
- X-ray techniques
- Exographs
- Screens
- Dark room practice
- Films
- High speed radiography
- Sterioradiography
- Microradiography
- X-ray diffraction
- X-ray fluorescence
- Safety

Eddy Current
- Coil theory
- Probe type coils
- Null type system
- Conductivity factors
- Inspection practice

Magnetic Inspection
- Principles
- Practice

Ultrasonic Inspection
- Principles
- Practice

Where equipments were too large to be demonstrated in class, as in radiography, a trip to a radiography lab was planned.

Appendix 7
Phase of Program Designed by Spectroscopy Society of Pittsburgh

Purpose

To give the student a concept of the range of electromagnetic radiations that may be used for analytical purposes; to demonstrate how X-rays can be used to identify compounds by X-ray diffraction patterns; to to show by a working example how the spectrograph can be used to give information about composition; to point out how color can be used as a means of making a quantitative determination, such as manganese in steel; to show that certain combinations of elements in organic compounds give definite characteristics that can be used to identify these combinations of elements in organic compounds; give characteristics that can be used to identify these combinations in unknown compounds.

The introductory session to this topic will include a showing of the movie, "The Spectrograph" placed in the audio-visual center of Chatham College by the Spectroscopy Society of Pittsburgh. At the same time one or two members of SSP will be on hand to give some further comments on the application of spectroscopy in a practical way with examples from each field as criminology, medicine, petroleum, etc.

Field Trip

A trip to some laboratory using most or all of the techniques covered is suggested.

Experiments

It is proposed that about seven experiments be set up to be worked on individually by students or in groups depending on the equipment available and the class size. Students could be required to perform all of them or a certain number of their choice. These are based on the assumption that there will be three or four 2-hour lab periods. Below is a brief outline of the experiments, what is to be done, and the SSP member responsible for writing it up in full.

X-ray diffraction—R. K. Scott

Debye-Scherer powder photographs and Geiger counter traces will be furnished for known compounds. Students will be asked to obtain spacing data from at least one of each type and compare data with information furnished from the literature.

Emission spectroscopy—James E. Paterson

Sample films to be furnished for inspection. Photographic enlargements covering a suitable spectral region are to be furnished to each student. He will be expected to suitably mount the strip all in one piece or in sections; construct a linear wave length scale adjacent to the spectra, and identify the principal lines.

Spectrophotometry—E. S. Hodge

The use of photoelectric colorimeter is outlined. The B and L Spectronic is to be used specifically. A series of potassium permanganate solutions covering about a 20 to 50 fold range is to be prepared. Students are to read the transmission of these solutions at at least four separate wave lengths, and values plotted for each wave length of %T vs concentration.

Todd-Fisher Spectranal—E. S. Hodge

Using several solutions demonstrate how certain elements in solution can be identified by visual means. Furnish several unknowns for students to analyze after becoming familiar with instrument and technique.

Infrared Spectroscopy—H. Lady

The infrared absorption curves of a number of related compounds will be presented to students and by careful comparisons they are to note what differences in bands can be assigned to functional groups or bondings such as—OH, —CO, —C-H, etc.

Mass Spectrometry—J. Schultz

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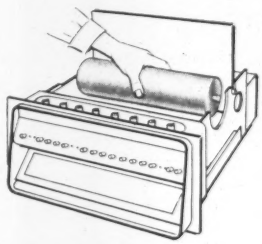

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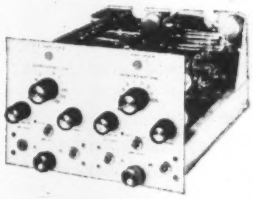

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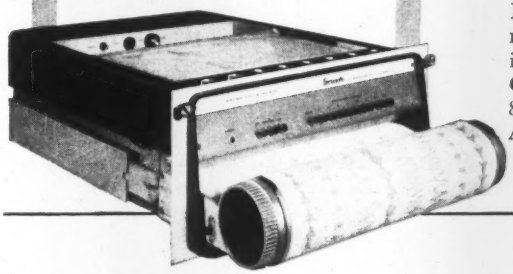

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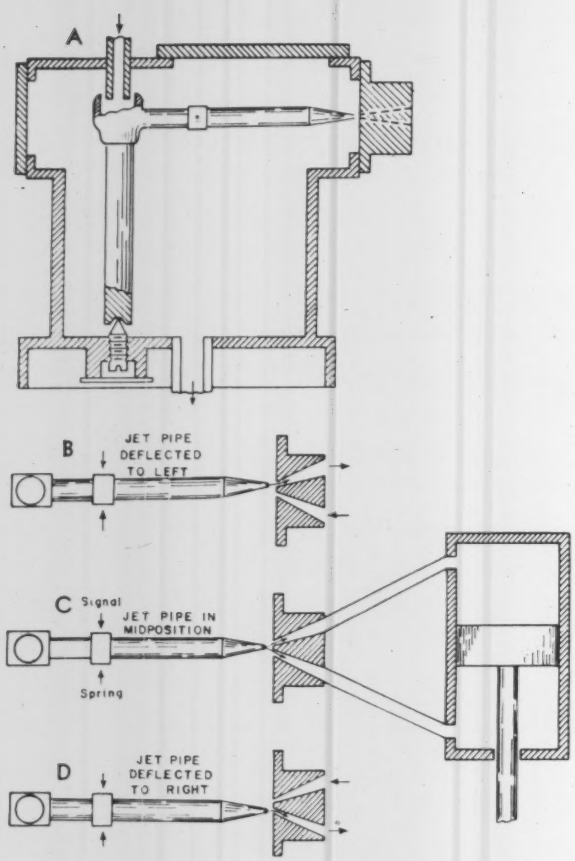


FIG. 1. JET-PIPE TYPE hydraulic controller is example of proportional-speed floating-control action.

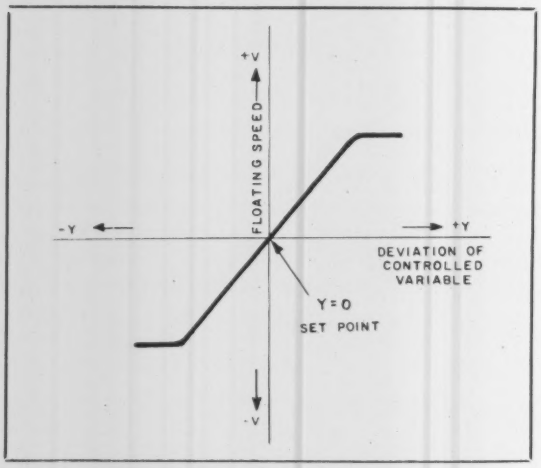


FIG. 2. FLOATING SPEED, applying to single or proportional-speed floating control action, is the rate of motion of the final control element.

A SINGLE-CAPACITANCE PROCESS will be considered because multiple-capacitance processes generally can be broken down into single capacitance processes plus dead time. Such an approximation yields quick results of practical value.

Floating action, as described here, will be *proportional-speed floating action*, i. e., it will be of a speed proportional to the actuating signal. Floating action (or reset) is the building block which can be developed into proportional-position as well as proportional-plus-reset action. Proportional-position action is obtained by adding feedback; proportional-plus-reset action results from adding floating to proportional-position action. Thus floating action can be used as the point of departure for other actions of increasing complexity; because it is the simplest solution for many process control problems it will be viewed first.

Controller with Floating action

A floating controller using the jet-pipe principle is shown in Fig. 1. Oil enters the jet pipe as indicated by the arrow at the top left (point A), and leaves the tip in a fine stream which is directed toward two receiving orifices. The jet pipe swings in practically frictionless bearings and is positioned by a signal system responding to the magnitude of the controlled variable. The receiving orifices are fixed and connect to an actuating cylinder. The piston in this cylinder is linked to the final control element (valve, damper, etc.)

With the jet pipe in the midposition, the oil stream leaving the jet pipe is equally divided between the two receiving orifices and the hydraulic pressure on each side of the piston is equal. Disregarding effects of load on the piston, the latter will stand still in this balanced condition.

If the jet pipe is deflected to the left, as illustrated at point B, the oil stream impinges more directly on one orifice than on the other; the pressure across the piston becomes unequal and the piston moves to the right. Oil is released through the lower orifice. The larger the jet-pipe deviation the greater will be the

Proportional-Speed Floating Action

Knowledge of the characteristics of proportional-speed floating action can help to determine its suitability for control of a specific process. A hydraulic controller serves to illustrate this control action; the conclusions are applicable to other controllers with equal action.

pressure difference across the piston and the faster it will move. This holds true within the limits of jet-pipe deflection from direct impingement over the upper orifice to direct impingement over the lower orifice. Stops prevent the jet pipe from moving beyond these limits.

The jet-pipe position depends on the difference between two forces, one obtained from the controlled variable and one from an adjustable spring. The set point is obtained by changing the compression of the spring. This results in a deflection (of the jet pipe) which is proportional to the deviation of the controlled variable from the set point.

Thus the two characteristics of floating action are obtained—(1) The motion of the final control element continues as long as the deviation of the controlled variable from the set point persists (disregarding mechanical limitations of the valve travel), and (2) the speed at which the final control element moves is proportional to the deviation of the controlled variable from the set point.

Analysis of the Controller

Fig. 2 illustrates the floating speed v, with which a final control element responds to a deviation y. The set point corresponds to $y = 0$. As the controlled variable deviates from the set point the speed of the final control element increases in proportion.

The ratio of floating speed to deviation is the *floating rate* (f) of a controller or:

$$f = \frac{v}{y} \qquad (1)$$

For example, raising the oil-supply pressure or using a spring with lower spring rate in the arrangement of Fig. 1 increases the floating rate, but once such adjustments are made the floating rate is fixed.

The speed with which a control valve moves is equal to the floating speed, hence

$$\dot{a} = v \qquad (2)$$

Combining equation (1) and (2) gives

$$\dot{a} = f\,y \qquad (3)$$

SYMBOLS

(Rather than expressing units in %, the non-dimensional fractional units are used in a number of cases. Thus 100% = 1, 50% = 0.5, etc.)

- a = displacement of final control element, fraction of full valve travel (full valve travel corresponds with maximum magnitude of manipulated variable).
- a_s = magnitude of step change in position of final control element, fraction of travel.
- $\dot{a}$ = speed of final control element, in/min.
- b = factor of self regulation.
- c = response rate of process, i.e., rate of change of controlled variable in proportion to process unbalance.
- f = floating rate of controller = v/y.
- g = gain of process = y_r/a_s.
- k = constant chosen from Table I for calculation of floating rate.
- S = proportional band, i.e., change of position in final control element (in percent of full travel) in proportion to change of controlled variable (in percent of maximum range).
- T_1 = time constant, min.
- T_2 = dead time, min.
- v = floating speed of controller, in/min.
- x = process unbalance = input-output, fraction of maximum magnitude of manipulated variable.
- x_i = initial process unbalance, resulting from load change or step input.
- y = deviation from set point, fraction of maximum range of the controlled variable.
- y_r = maximum change of controlled variable after step change of input, when controller is disconnected, in fraction of maximum range of the controlled variable.
- $\dot{y}$ = rate of change of controlled variable, derivative of y.
- $\ddot{y}$ = derivative of $\dot{y}$.
- Δ = decrement, i.e., ratio between successive amplitudes of an oscillation.

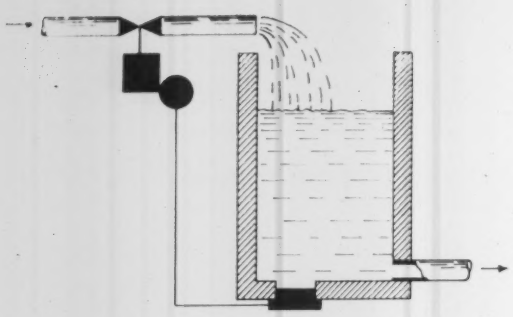


FIG. 3. LEVEL CONTROL in a tank is used for process analysis problem.

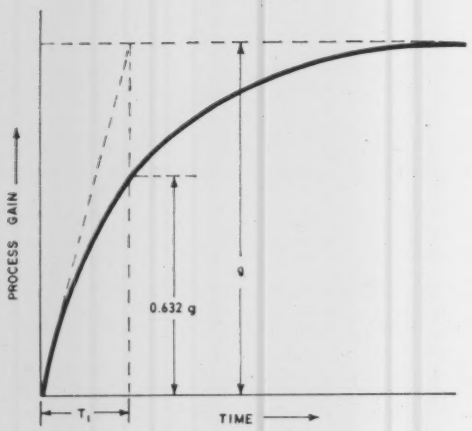


FIG. 4. TYPICAL RESPONSE of single-capacity process shows process gain reaching constant value with time.

Analysis of the Process

Whether or not a controller with floating action is suited for a process and what the floating rate should be depends on the characteristics of the process. Fig. 3 illustrates control of liquid level. The response characteristics of the process can be obtained by disconnecting the controller and suddenly changing the control-valve position.

Before this step change, the rate of flow into the tank equals the rate of flow out of it. Immediately after the step change (assuming it is in direction of an increase in valve opening) the flow *in* (which corresponds with the manipulated variable) exceeds the flow *out*. This process unbalance results in an increase of level in the tank. The rise in head leads to an increase in flow *out*. The result is that after the step change the level will rise to a point where the flow *out* is again equal to the flow in. When this condition is reached, the initial process unbalance has been reduced to zero.

The ability of a process to balance at a new value by means of its own physical nature is its *self-regulation*, expressed by:

$$x = a_s - by \qquad (4)$$

where x is the process unbalance (input minus output) expressed as a fraction of the maximum input with fully opened valve—i.e., of the maximum magnitude of the manipulated variable; a_s is the step change of position of the final control element expressed as fraction of full travel (linearized characteristics); b is the factor of self-regulation; and y is the change of magnitude of the controlled variable expressed as fraction of its maximum value. (This would correspond to the balanced condition obtained after the final control element has been set for maximum input.) For example, let the rate of input flow at fully-open valve (Fig. 3) be 200 gallons per minute. A difference of say 10 gpm between flow *in* and flow *out* is then 5% of maximum flow, or $x = 0.05$.

Suppose next that the valve remains fully opened. The level would rise to, say, 20 ft before the flow *out* equals the flow *in*. The maximum level range is thus 20 feet. A step change of 2 ft corresponds to 10% of this maximum attainable level, or $y = 0.1$.

Before the step change, $y = 0$ (this condition applies also immediately after the step change). Hence, at that moment $x_i = a_s$, where x_i is the initial (maximum) unbalance. Once conditions are again balanced, x becomes 0 and $a_s = b\,y_f$ where y_f is the total change of the controlled variable.

The factor of self-regulation (b) is therefore expressed by

$$b = a_s/y_f$$

Process Gain

The gain (g) of a process is usually defined as the change of controlled variable per unit change of position of the final control element:

$$g = y_f/a_s$$

Comparison with the factor of self-regulation shows that it is the inverse of the gain. Equation (4) now may be written

$$x = a_s - y/g \qquad (5)$$

Response Rate

The greater the difference between flow in and flow out, the faster the level will rise. This means that the rate of change of the controlled variable is proportional to the process unbalance at any given moment:

$$\dot{y} = c\,x \qquad (6)$$

where c = constant, which expresses the response rate of a process as will be shown.

It results from the definition of x, that if the step change would be extended from a fully closed to a fully open valve, the process unbalance immediately after this change would be equal unity. In this special case $\dot{y} = c$. This shows that c is the maximum speed of the controlled variable that would occur immedi-

ately after the final control element moves through its full stroke. The magnitude c will be called the *response rate* of the specific process.

Time Constant

Fig. 4 shows the typical response of a single-capacitance process. A dashed line is drawn tangent to the initial (the maximum) slope of the response. This corresponds to the definition of the response rate c. As the diagram shows, $c = g/T_1$. This can be rewritten as

$$T_1 = g/c \qquad (7)$$

The time T_1 is defined as the time constant of the process and is equal to the time that is required to produce 63.2% of the total change of the controlled variable.

Analysis of the Loop

After analyzing controller and process as separate parts, they will now be connected into a closed loop. The step change a_s is replaced by a load change which produces an initial unbalance x_i which is gradually modified by the corrective action (change of position of the final control element), or a. Equation (5) then becomes

$$x = x_i - a - y/g \qquad (8)$$

where a is now the progressive positioning of the final control element due to controller action.

Equation (6) can be used to substitute for x in equation (8):

$$\dot{y}/c = x_i - a - y/g \qquad (9)$$

If equation (9) is differentiated and rearranged:

$$\ddot{y} + (c/g)\dot{y} + c\dot{a} = 0 \qquad (10)$$

If equation (3) is substituted in (10):

$$\ddot{y} + (c/g)\dot{y} + cfy = 0 \qquad (11)$$

This shows that the corrective action of the controller is a function of the gain (g), the response rate (c) of the process, and the floating rate of the controller ($\dot{v}$).

As the process gain is the inverse value of the self-regulation, it follows that a process without self-regulation has infinite gain, in which case, equation (11) reduces to

$$\ddot{y} + cf = 0$$

This equation is that of a physical system without damping, but with mass and spring force. Such a system is inherently unstable. This is a proof of the well-known fact that floating control cannot be used in a process without self-regulation.

Adjustments of Floating Rate

Substitution of equation (7) in (11) gives

$$\ddot{y} + (1/T_1)\dot{y} + (g/T_1)fy = 0 \qquad (12)$$

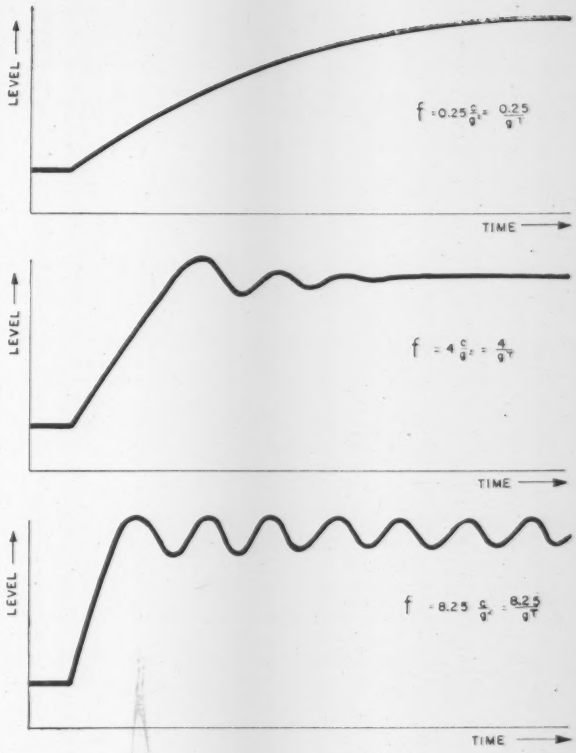


FIG. 5. THREE POSSIBLE responses are (1) critical damping, (2) damped oscillations, and (3) unstable condition.

The roots of the characteristic equation are

$$r = -(1/2T_1)(1 \pm \sqrt{1 - 4gfT_1}) \qquad (13)$$

from which it follows that the process is critically damped for a floating rate of

$$f = 1/4g\,T_1 \qquad (14)$$

Fig. 5 shows three possible responses.

The floating rate should obviously be as high as possible to provide fastest corrective action for any deviation of the controlled variable from its set point. On the other hand, the floating rate must not exceed that magnitude that causes the controlled variable to continuously oscillate around the control point. A few rapidly subsiding oscillations are generally permissible and the normal procedure in process control is to operate with a ¼-decay ratio (which means that the amplitude of each succeeding oscillation is ¼ of the preceding one). This is identical with a decrement of 4, which means that the ratio of one amplitude to the next is 4:1. The decrement is designated by Δ and:

$$\Delta = \exp 2\pi\sqrt{1/4T_1\,gf - 1}$$

from which it follows that

$$f = \frac{1}{gT_1}\left[\frac{\pi^2}{(\ln \Delta)^2} + \frac{1}{4}\right]$$

TABLE 1—CONSTANTS FOR CALCULATION OF FLOATING RATE (EQUATION 16)

T_1/T_2	k
> 25	5
12-25	4
6-12	3
2-6	2
1-2	1.5
< 1	1

TABLE 2—FACTORS FOR ADJUSTING FLOATING RATE OF INSTALLED SYSTEMS

T_1/T_2	Increase of Stroke Time
25-100	10 times
10-25	5 times
4-10	3 times
< 4	2 times

Beyond $T_1/T_2 = 100$ it will be hard to produce oscillation.

Calculation of f for the desired ¼-decay ratio by means of this equation gives

$$f = 5.4/gT_1 \qquad (15)$$

Comparison between equations (14) and (15) shows that the method of the ¼-decay ratio allows operation more than 20 times faster than does operation for critically damped conditions.

If dead time T_2 is present, or if a multi-capacitance process is broken down into a single time constant plus dead time, allowance must be made correspondingly. A practical method with sufficient accuracy for most applications is based on the equation

$$f = \frac{k}{g\,(T_1 + T_2)} \qquad (16)$$

where k is a number to be chosen from Table 1. Although for analytical purposes it is preferable to use nondimensional magnitudes, in practical applications equation (16) can be used with any consistent units.

Example

For example, a temperature-controlled process has a gain of 5F° per inch of valve motion, a dead time of 1 minute, and time constant of 3 minutes. Substituting values in equation (16) gives a floating rate of $f = 2/5(3 + 1)$, or 0.1 in/min/°F.

A method for determining the floating rate in an actually installed system consists of the following three steps:

(1) Increase the floating rate until after a small change of set point the control system just begins to oscillate continuously without changes in amplitude.

(2) Now apply a signal which is large enough to obtain the maximum speed of the final control element and measure the time needed by the final control element to complete its stroke under these conditions.

(3) Estimate the relation of time constant to dead time (T_1/T_2) and decrease the floating rate so that the stroke time measured under (2) is increased by the factor listed in Table 2.

For example, the floating rate of a control system is increased to a point where the system begins to oscillate. At this point, the stroke time of the final control element is measured and found to be 6 seconds. The time constant is estimated to be 12 times the dead time. Hence, according to Table 2, the stroke time should be increased 5 times, i.e. to 30 seconds.

The factor that limits the application of floating action is the floating rate. Where the control system requires a very slow floating rate, correction for a deviation can become so slow that the time which elapses before the controlled variable returns to the control point is longer than permissible for satisfactory control.

A slow floating rate may be compared with a wide proportional band (a low gain of a proportional-position controller). In either case, corrective action is limited in the interest of stability.

According to the Ziegler-Nichols method, the gain (S) of a proportional-position controller can be adjusted by the equation

$$S = T_1/g\,T_2 \qquad (17)$$

Therefore, low T_1/T_2 ratios diminish the response of proportional-position action, whereas they affect floating control only to the extent of coefficient k. As shown in Table 1, the maximum effect of k does not exceed the ratio 5:1.

The magnitude of the sum of T_1 plus T_2, however, is of much more pronounced effect on floating control than it would be on proportional-position action.

A typical example is a temperature-controlled process which has a time constant of, say, 3 minutes and a dead time of 1 minute. According to equation 16, the floating rate would be

$$f = \tfrac{1}{2}g$$

while according to equation (17) the gain of a proportional-position controller would be

$$S = 3/g$$

A ratio of

$$S/f = 6 \qquad (18)$$

may then be established.

On the other hand, a pH-control system may have, for example, a time constant of 0.02 minute, and a dead time of 0.48 minute. In this case, $f = 2/g$ and $S = 0.04/g$ or

$$S/f = 0.02 \qquad (19)$$

Comparing proportional-position and floating control by means of equations (18) and (19) shows that the response of proportional-position action is probably better in the first case, but worse than floating action in the latter.

In conclusion, it can be stated that floating control is particularly valuable where low T_1/T_2 ratios combined with small absolute values of T_1 and T_2 exist.

Process Control Systems

FRED D. MARTON, Instruments Publishing Company

GLASS FEEDER TEMPERATURE CONTROL

Variable: Temperature of bath to be controlled at 2100°F to obtain uniform viscosity.

Glass feeders must supply molten glass of uniform viscosity to glass forming or molding apparatus in order to insure a product uniform in weight and thickness. Close control of the temperature of the bath is required. This pneumatic control system has proved itself in many installations.

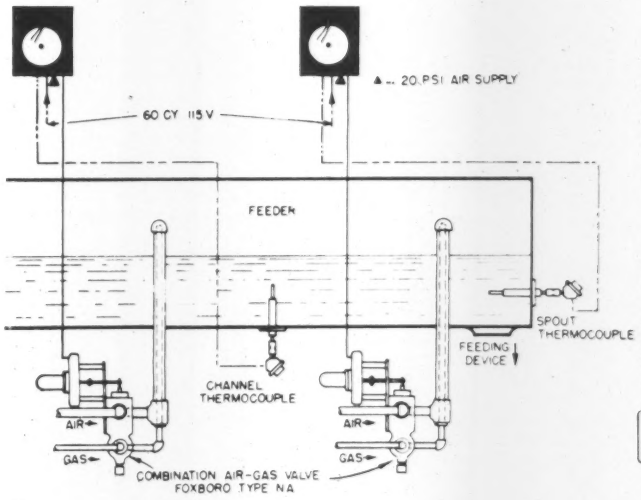
Primary elements are thermocouples of the Pt/Pt-Rh type which are satisfactory at temperatures of 2100° to 2300°F, the approximate control temperature of the bath. The thermocouples are protected by platinum thimbles or sleeves at the hot end. Channel thermocouples are inserted through the refractory side wall approximately 4″ below the level and protrude 2″ to 3″ into the molten bath. Spout thermocouples (at the spout where the liquid glass emerges) are installed about 0.5″ below the level of the molten glass. Thermocouples have proved to be more reliable than radiation elements.

The control system is pneumatic; the controllers are Dynalog EMF Hyper-Reset Temperature Controllers.

Control modes include proportional, rate and reset to adjust quickly for changes in glass temperature and changes in demand.

Final elements are adjustable-port-type valves, either single valves (for inspirated fuel/air mixing systems) or dual valves with fuel-and-air control. Such valves are suitable for gas or oil fuel systems. To assure precise control, valve positioners are used.

Source: The Foxboro Company, Foxboro, Mass.; also Application Engineering Data Sheet 320-10.



SINGLE-ELEMENT PILOT-OPERATED FEEDWATER CONTROL

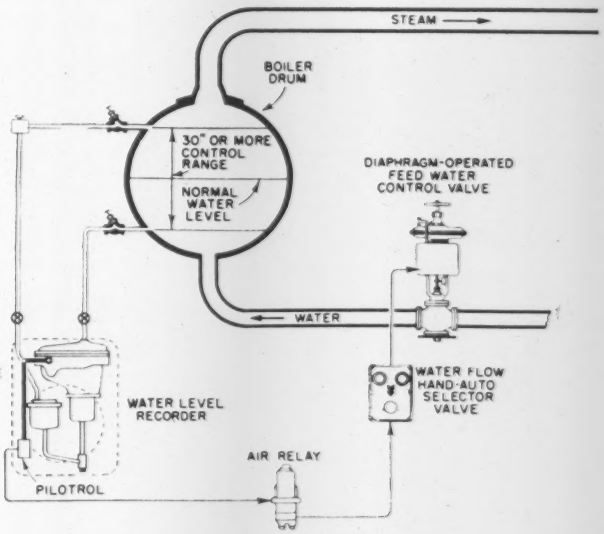
This pilot-operated feedwater control system uses compressed air as the control medium. Although the system requires an external source of power, it has many advantages over the self-operated type. It is based on level measurement.

Tank level is measured by a pressure-differential measuring device, which operates a Pilotrol. The Pilotrol is a flapper-nozzle air-pilot proportional controller with adjustable set point and proportional band. It is connected mechanically to the d/p level-detecting element and mounted inside the case of the water-level recorder unit. The output from the Pilotrol goes to a Standatrol Air Relay. This is a 4-volume controller with an auxiliary chamber for automatic reset. From the Air Relay the signal goes through a Hand-Automatic Selector Valve to the feedwater control valve in the feedwater line.

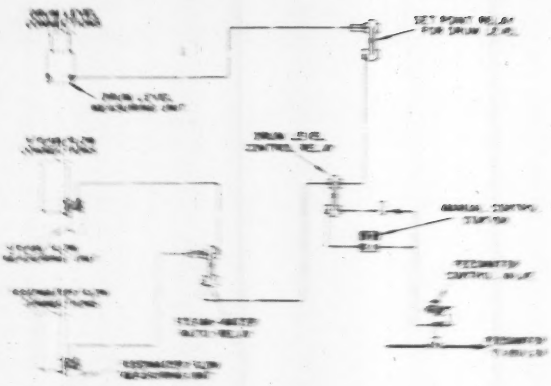
Inasmuch as automatic reset is provided, a wider proportional band can be used on the level controller, minimizing the level and flow cycling which takes place on a change in load. Another advantage in this type of system is that it permits the installation of a Hand-Automatic Selector Valve at the control center, so that remote manual control is provided during start-up and abnormal operating conditions.

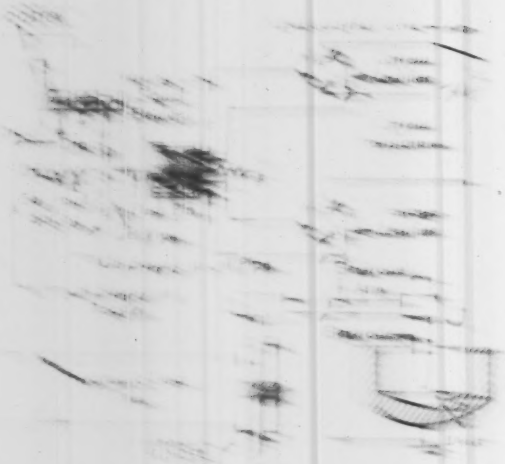
A pilot-operated valve positioner containing a characterizing cam also can be installed on the feedwater regulating valve, permitting matching the valve characteristics to the requirements on the system.

Source: Bailey Meter Co., Cleveland, Ohio.



THREE-ELEMENT FEEDWATER CONTROL FOR BOILER

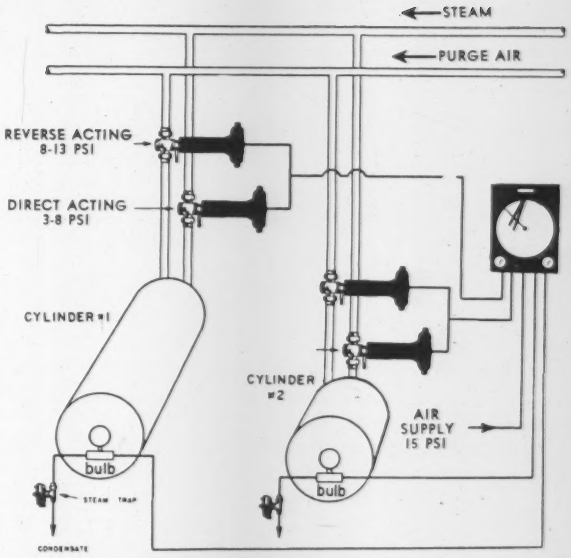




SLASHER CYLINDER TEMPERATURE CONTROL

The temperature treatment a yarn receives on the cylinders of a slasher (whether it be a two-cylinder cotton type or a thirteen-cylinder design for rayon) is of great importance for the final product. Accurate temperature control not only improves the quality of the woven textiles but also increases production.

Control is exercised by regulating the *pressure of the steam* entering the coils, resulting in control of the cylinder temperatures. In this system a dual direct-acting recording controller, pneumatic type, is used which has wide-range proportional (0 to 150%) mode of control with manual reset. (Other installations of the same type use a narrower band with automatic reset). A dual controller is used to control two cylinders. A seven-cylinder slasher would include four dual instruments with size box temperature also being under control. Each output signal is piped to two control valves, one (direct acting) in the steam line, and the other one (reverse acting) in the purge-air line. Purge air keeps the cylinders cleared of condensate to minimize lag. The range of the 3-15 psig output signal is split so that 3 to 8-psig air pressure is used to control the steam valves, and 8 to 13-psig air operates the air purge valve. The valves are of the characterized V-port type with single seats.



Temperature is controlled within 3°F.

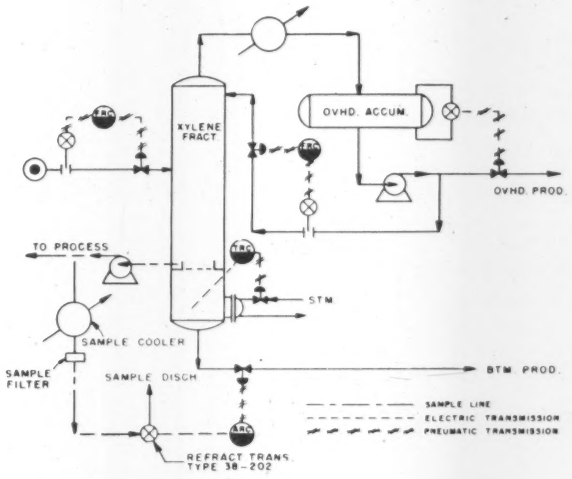
Source: The Powers Regulator Co., Skokie, Ill., "Slasher and Size Room Controls Manual."

PROCESS REFRACTOMETER CONTROLS ORTHO-XYLENE CONCENTRATION IN XYLENE FRACTIONATING OPERATION

In xylene fractionating, ortho-xylene is separated from meta-xylene and para-xylene*. Continuous stream analysis by refractometry is used in this xylene fractionating column to control the ortho-xylene concentration.

The refractometer sample point was determined after a column profile of refractive index had been worked out. This sample point is in the liquid on a tray near the bottom where ortho-xylene is trapped out.

*The isomers of xylene are of the same chemical equation formula—$C_6H_4(CH_3)$; the differences between ortho-, meta-, and para-xylene are in the benzene ring configuration.



The essential stream data are:

COMPONENTS	CONCENTRATION (MOL %)
Ethyl Benzene	1.3
Para-Xylene	9.2
Meta-Xylene	38.3
Ortho-Xylene	51.2

Under these conditions, the refractometer was furnished with a sensitivity of 0.001 refractive index units full scale, corresponding to approximately a concentration change in ortho-xylene of 11 weight percent. One chart division, therefore, equals a 0.1 weight percent change.

The 0-50-mv dc output signal from the refractometer transmitter goes to an electromechanical potentiometer recorder-controller receiver (ARC). This signal is converted to a 3-15-psi controlled output air signal which actuates the tower bottom draw-off valve directly. This type of closed-loop control provides for optimum process operation resulting in increased profits through production of maximum yields of quality end product.

Other tower instrumentation includes:

(1) TRC in the bottom reboiler, steam-inlet which controls the heat input to the column, required for distillation separation of the component.

(2). FRC in the reflux to the tower controlling this flow-rate which, together with the bottom TRC, determines successful column operation.

(3). Second FRC on the feed to the column which maintains a predetermined rate of flow. The overhead accumulator instrumentation is a liquid-level controller for maintaining the rate of condensed overhead product draw-off.

Source: Consolidated Electrodynamics Corp., Pasadena, Calif.

THREE-ELEMENT FEEDWATER CONTROL FOR BOILER

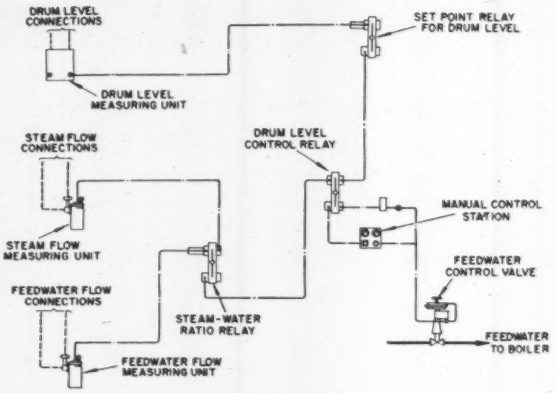
Control of water to feed the boilers of a modern power plant depends on various conditions and can be achieved in different ways. The selection of the proper system is influenced by the boiler design, the type of load, the water pressure, the type of pump, the presence of solids in the boiler drum, etc.

Three-element control was chosen for two blast-furnace-gas-fired boilers supplying steam to the throttle of a topping turbo-generator rated at 15,000 kw and furnishing 25-cps ac. The boilers have a rated capacity of 250,000 lb/hr each, and produce 900-psig steam at 900°F. T. T. They are of the vertical two-drum type with water-cooled walls and a water-cooled furnace bottom and are equipped with super-heater, economizer, and air heater. A feedwater treating system purifies the raw water pumped from a series of lakes.

In the illustration the three controlling elements of the feedwater control system are shown—(1) drum level, (2) steam flow, and (3) feedwater flow. The feedwater flow rate and steamflow rate signals are fed into a *steam-water ratio relay*. The resulting ratio (steam/water) signal is sent into the drum-level control relay whose pneumatic output operates the actuator of the control valve in the feedwater line.

Drum level transmitter, Type FRB, uses a hollow ring rotating about an inverted knife edge to produce a pneumatic signal linear with the pressure differential imposed on the measuring element. Steam flow and feedwater flow transmitters, Model 50, are of the force-balance high-pressure type which has an adjustable proportional band.

The signal from the drum-level measuring unit is connected to a set-point relay for the drum level and



the signal leaving it is indicative of any departure of drum level from standard value. This signal is fed into a separate chamber of the drum-level control relay, and indicates the need of any changes in feedwater-flow to bring level back to normal value.

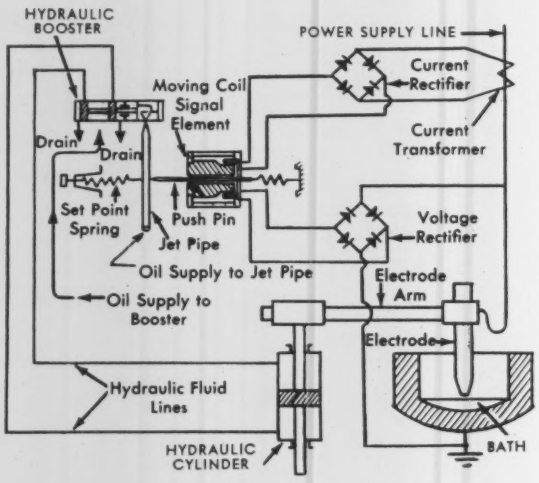
The three relays are force-balance type ratio totalizers. The set point relay and the steam-water ratio relay are equipped with tension spring attachments on one of the loading elements. The 4″ control valve is equipped with a positioner to achieve accurate control.

A manual control station (on the boiler panel) permits taking over this automatic system in event of emergency or malfunctioning.

Source: Hagan Chemicals & Controls, Inc.; also J. P. Katzenmeyer, "Instrumentation of a Modern Steam-Generating Facility," *Instruments and Automation*, June 1955.

ARC FURNACE CONTROL

Energy consumption of an electric furnace usually is controlled by varying the intensity of the arc. The desired intensity is maintained through control of arc *impedance* of each electrode. The arc impedance is detected by use of a "moving coil signal element" which has two coils and a magnet. One coil responds to a current signal; the other to a voltage signal. The output pin of this element thus moves in proportion to the *ratio* of arc current to arc voltage, or arc impedance. The system remains in equilibrium so long as a pre-determined ratio of arc-current to arc-voltage remains constant. This is adjustable via the set-point spring shown.



This detector-element push pin moves a jet pipe in a hydraulic circuit (Askania Jet-Pipe Regulator) under 100 to 400 psig pressure. By impinging more or less oil on two holes, a pressure differential is created which moves the piston of a hydraulic cylinder. The cylinder positions the electrodes with a *speed* directly proportional to the magnitude of the error signal in the electric circuit, thus restoring the set-point impedance. To amplify the force required to move the heavy electrodes, a hydraulic booster is inserted into the circuit.

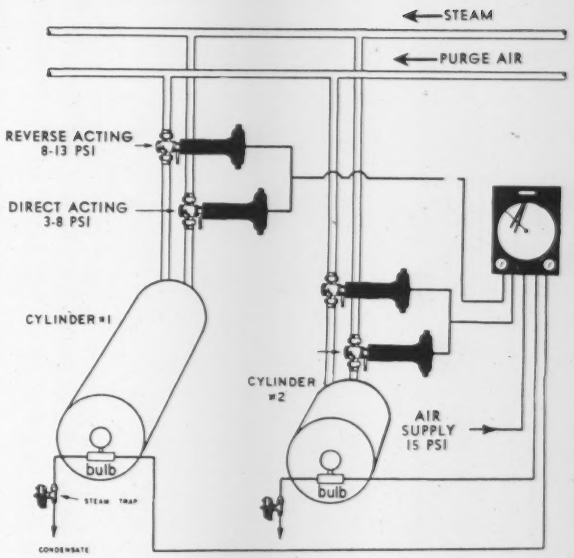
Mode of control is proportional speed floating. This, plus rapid hydraulic positioning, gives stable sensitive control.

Source: GPE Controls, Inc., Chicago, Ill., Application Bulletin 33.2.

SLASHER CYLINDER TEMPERATURE CONTROL

The temperature treatment a yarn receives on the cylinders of a slasher (whether it be a two-cylinder cotton type or a thirteen-cylinder design for rayon) is of great importance for the final product. Accurate temperature control not only improves the quality of the woven textiles but also increases production.

Control is exercised by regulating the *pressure of the steam* entering the coils, resulting in control of the cylinder temperatures. In this system a dual direct-acting recording controller, pneumatic type, is used which has wide-range proportional (0 to 150%) mode of control with manual reset. (Other installations of the same type use a narrower band with automatic reset). A dual controller is used to control two cylinders. A seven-cylinder slasher would include four dual instruments with size box temperature also being under control. Each output signal is piped to two control valves, one (direct acting) in the steam line, and the other one (reverse acting) in the purge-air line. Purge air keeps the cylinders cleared of condensate to minimize lag. The range of the 3-15 psig output signal is split so that 3 to 8-psig air pressure is used to control the steam valves, and 8 to 13-psig air operates the air purge valve. The valves are of the characterized V-port type with single seats.



Temperature is controlled within 3°F.

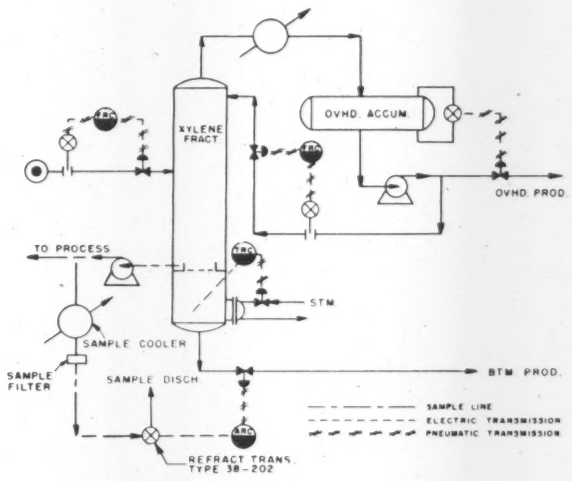
Source: The Powers Regulator Co., Skokie, Ill., "Slasher and Size Room Controls Manual."

PROCESS REFRACTOMETER CONTROLS ORTHO-XYLENE CONCENTRATION IN XYLENE FRACTIONATING OPERATION

In xylene fractionating, ortho-xylene is separated from meta-xylene and para-xylene*. Continuous stream analysis by refractometry is used in this xylene fractionating column to control the ortho-xylene concentration.

The refractometer sample point was determined after a column profile of refractive index had been worked out. This sample point is in the liquid on a tray near the bottom where ortho-xylene is trapped out.

*The isomers of xylene are of the same chemical equation formula—$C_6H_4(CH_3)$; the differences between ortho-, meta-, and para-xylene are in the benzene ring configuration.



The essential stream data are:

COMPONENTS	CONCENTRATION (MOL %)
Ethyl Benzene	1.3
Para-Xylene	9.2
Meta-Xylene	38.3
Ortho-Xylene	51.2

Under these conditions, the refractometer was furnished with a sensitivity of 0.001 refractive index units full scale, corresponding to approximately a concentration change in ortho-xylene of 11 weight percent. One chart division, therefore, equals a 0.1 weight percent change.

The 0-50-mv dc output signal from the refractometer transmitter goes to an electromechanical potentiometer recorder-controller receiver (ARC). This signal is converted to a 3-15-psi controlled output air signal which actuates the tower bottom draw-off valve directly. This type of closed-loop control provides for optimum process operation resulting in increased profits through production of maximum yields of quality end product.

Other tower instrumentation includes:

(1) TRC in the bottom reboiler, steam-inlet which controls the heat input to the column, required for distillation separation of the component.

(2). FRC in the reflux to the tower controlling this flow-rate which, together with the bottom TRC, determines successful column operation.

(3). Second FRC on the feed to the column which maintains a predetermined rate of flow. The overhead accumulator instrumentation is a liquid-level controller for maintaining the rate of condensed overhead product draw-off.

Source: Consolidated Electrodynamics Corp., Pasadena, Calif.

H. F. BOTTCHER
E. R. Squibb & Sons

Air pressure control is key to uninterrupted fermentation growth of "miracle drugs" Streptomycin, Penicillin and Mycostatin.

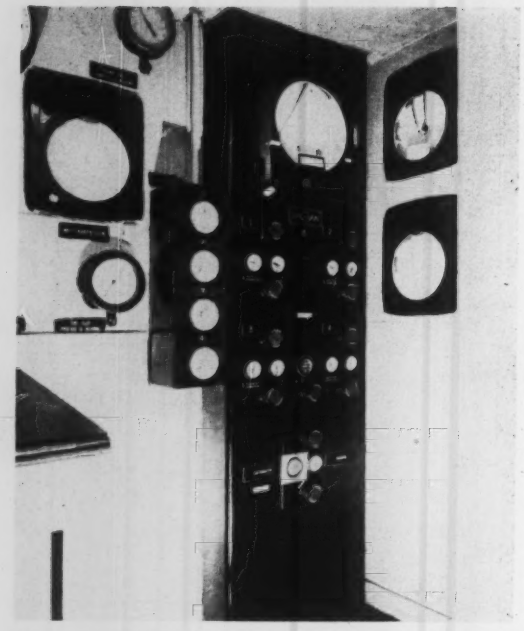


FIG. 1. FINGERTIP CONTROL for the entire system is provided at this central control panel. The Ring Balance air flow meter (top) indicates volume of air being bled to atmosphere, thus determining number of compressors that should be in operation. Manual-automatic stations permit remote positioning of bleed and inlet control valves when taking compressors in and out of service. Automatic-manual set-point relays are shown at bottom center.

Automatic Air

E. R. SQUIBB & SONS, Division of Olin Mathieson Plant, operates (at New Brunswick, N. J.) one of the world's largest plants manufacturing antibiotics. One of the major production problems is maintaining a dependable, uninterrupted source of air at precise pressures.

Each fermentor requires large volumes of air (on which the micro-organisms live) to produce the desired antibiotics. Any interruption in this air supply directly affects the growth of the organisms.

The process air installation consists of four 4-stage centrifugal compressors delivering air at 25 psig. Each compressor is driven by a synchronous motor rated at 1750 hp, 4160 volts and 162 amps. A common suction manifold feeds all four compressors. Two discharge headers, each serving two compressors, combine to form a common header downstream of the aftercoolers. A bypass is connected to the two discharge headers so that surplus air can be diverted to atmosphere through a silencer. This bypass plays a major role in the operation of the process.

Tank Changeover

The load varies when a fermentation tank is added to or removed from the line. Tank changeover, if brought about too quickly, can cause one or more compressors to "kick out" due to unloading (surging) or overloading, depending on the fluctuation of plant air demand. To prevent compressors from kicking out or overloading, it was necessary to operate more compressors than actually needed. At the same time, to guard against unloading when the plant air demand decreased, an excessive amount of air had to be dumped via the bypass to atmosphere. After extensive investigation by the Squibb Engineering Department, an automatic control system was worked out in conjunction with Hagan Chemicals & Controls, Inc., Pittsburgh. (Fig. 1).

Automatic Air Control

The automatic control system (Fig. 1) maintains a constant supply of process air at precise pressure and also prevents overloading and surging of compressor motors. This is accomplished through continuous automatic adjustment of compressor motor load between minimum and maximum allowable limits, and by opening an atmosphere bleed valve when process requirements fall below the minimum output of the operating compressors.

The *ratio totalizer* (lower left in Fig. 2) is a pneumatic force-balance relay that accurately combines two input signal pressures to produce a single output signal. This master pressure regulator acts to maintain the process air pressure (first input signal) on

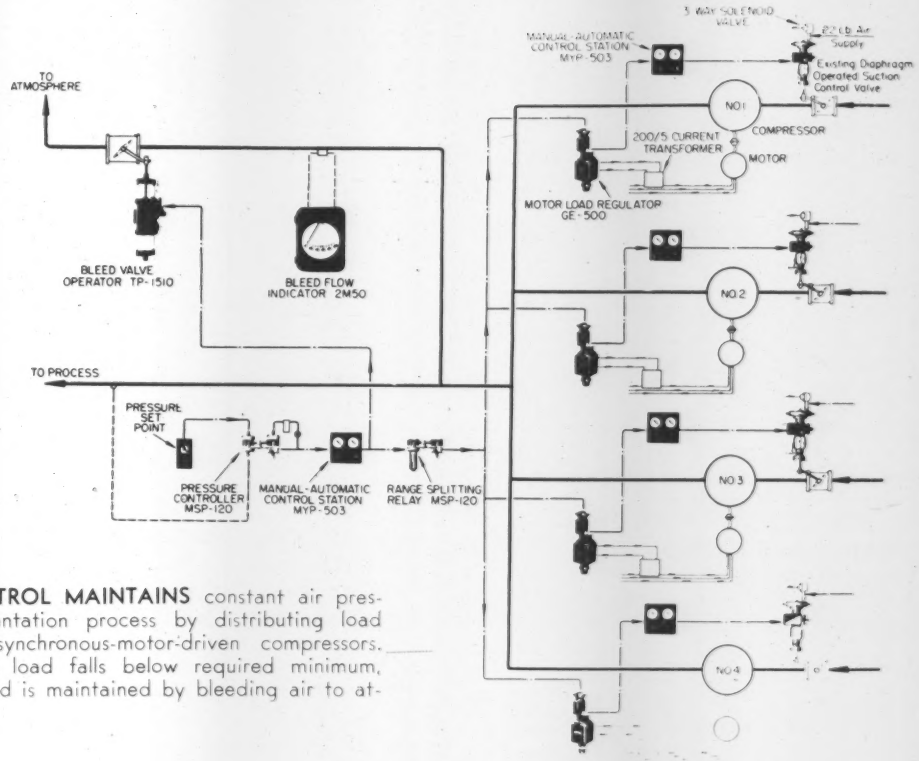


FIG. 2. CONTROL MAINTAINS constant air pressure to fermentation process by distributing load among four synchronous-motor-driven compressors. When process load falls below required minimum, compressor load is maintained by bleeding air to atmosphere.

Control for Fermentation Process

one of its diaphragms exactly equal to the pneumatic set-point loading (second input signal) on an opposing diaphragm. It incorporates proportional-band control action and automatic reset.

The output signal from this pressure controller is transmitted to the motor load regulators (Fig. 2, center) which control motor load from allowable maximum to minimum through a portion of the signal range. Below minimum motor load, the signal controls the bleed valve to atmosphere through the remaining portion of the signal range (Fig. 2, upper left).

The motor load regulator is an electro-pneumatic, force-balance device which measures motor load by sensing current changes through a current transformer in one phase of the motor feeder circuit. It controls motor load by means of a pneumatic signal sent out to command the position of a butterfly valve in the compressor inlet line.

A Ring Balance indicating air flow meter (Fig. 1) shows the operator when air is being bled to atmosphere and provides the basis for determining how many compressor units should be in operation.

Manual-automatic stations located on the panel with the bleed flow indicator permit remote manual positioning of the bleed valve and the inlet control valves when taking compressors in and out of operation.

An electric interlock system causes the inlet control valve to be closed automatically when the corresponding compressor motor is shut down. A three-way solenoid valve, which interrupts the control signal to the suction valve positioner, it all that is required to accomplish this.

Through the savings in time, reduced current costs, and more efficient operation with less loss of product and plant down-time, it is believed the automatic control system paid for itself in eighteen months.

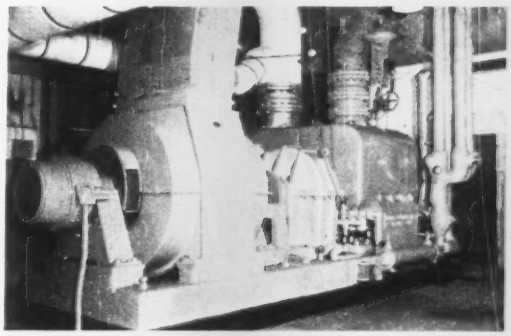
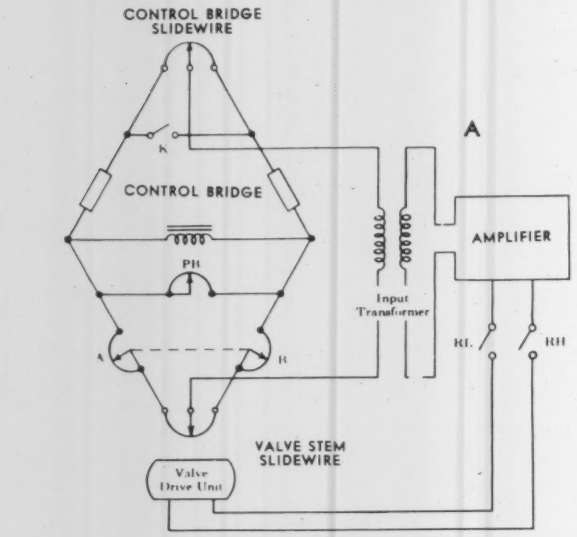


FIG. 3. ONE OF THE four centrifugal compressors delivering air at 25 psig to the fermentation tanks.

Response of

Response of combination valve actuators was presented in the September and October (1958) issues. We continue with response data for electric valve actuators.

DYNAMIC RESPONSE of valve actuators can be plotted or expressed in mathematical form for use in mathematical analysis or simulation. The frequency-response curves, as tentatively standardized by the ASME-IRD Dynamic Systems Committee, plot magnitude ratio vs frequency, and show phase shift (in degrees) vs frequency. Magnitude ratio is output amplitude over input amplitude; phase shift ϕ is expressed by $\phi = 360\ L/P$, where L is the time by which the output is lagging, and P is the period or time per cycle, which is the reciprocal of the frequency.



Basic Electric Actuators

Fig. 1 is a block diagram that shows the essential elements of typical electric actuators. Various techniques are used to sense the valve position and compare it with the input signal.

Conoflow Models D-62XD and D-62XW

Fig. 2 shows the compact Model D-62XD all-electric actuator which mounts on top of the valve by means of an integral mounting yoke. It uses a system as in Fig. 1B, with LDVT. It responds to a *current* signal of 1 to 5 ma dc. The signal is measured in a *balancing amplifier*, which compares the signal with a feedback signal from the actuator. Any unbalance is amplified and the signal drives the reversible a-c motor until balance is restored. Motion of the stem is thus proportional to the signal.

Strokes from ¼″ to 2″ can be obtained. Stroking speed is 2.5″ min at 500-lb maximum thrust, and up to 8″/min with lower maximum thrust. Repositioning accuracy is ½% of full scale input (or total stem travel). Self-locking gears provide positive-position in case of power failure.

Fig. 2 shows the Model D-62XW. This newer model is a *voltage-balance* system similar to that shown in Fig. 1A. It responds to pushbutton, rheostat or automatic control in voltage balance systems (or position adjustment types). It incorporates a high-resolution (135 and 1000 ohms) slidewire feedback unit and rack-and-pinion and worm drive, providing positive locking and stable positioning unaffected by sudden load changes on stem. Travel is ½″ to 4″ with speeds from 8.5″/min at 100-lb load to 2.5″/min at 350-lb. load.

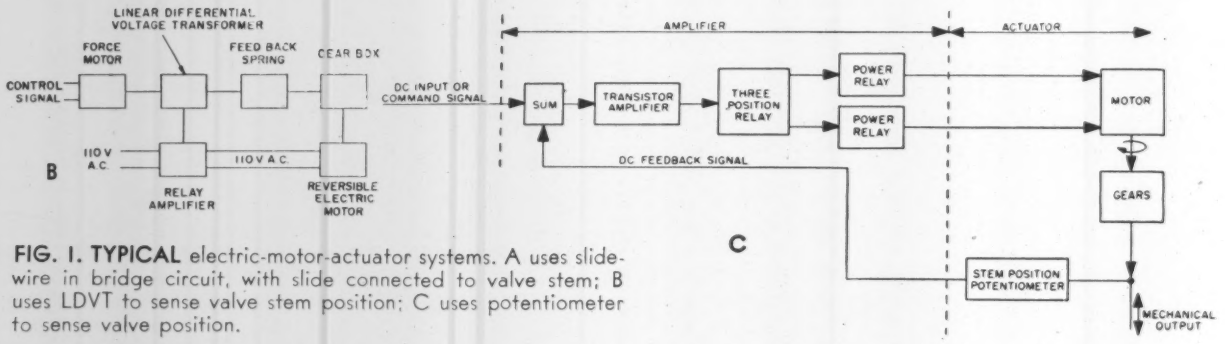


FIG. 1. TYPICAL electric-motor-actuator systems. A uses slidewire in bridge circuit, with slide connected to valve stem; B uses LDVT to sense valve stem position; C uses potentiometer to sense valve position.

Electric Valve Actuators

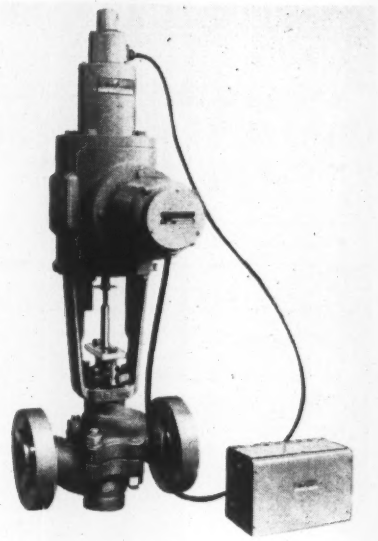
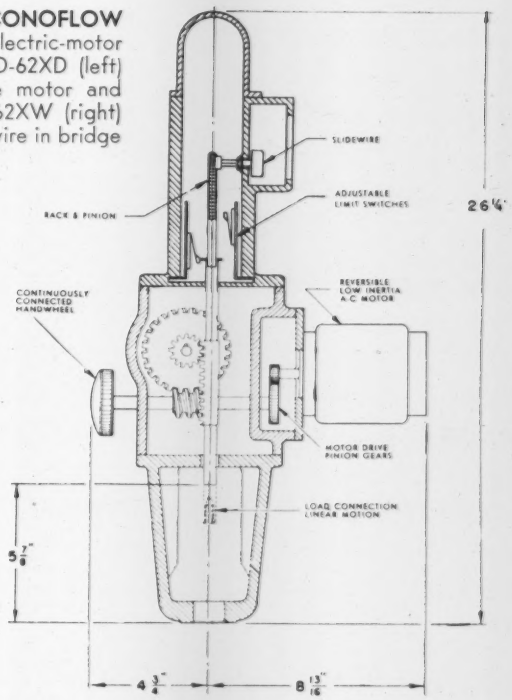


FIG. 2. CONOFLOW geared electric-motor actuator D-62XD (left) uses force motor and LVDT. D-62XW (right) uses slidewire in bridge circuit.



General Controls Co.

Fig. 3 shows the General Controls Co. electric-motor-type valve actuator and AV-16B valve. A schematic of the SD MA-11A1000 A actuator is shown in Fig. 3B. Rated torque at output shaft of this latter 1-second actuator is 50 in-lb maximum. The shaft speed provides 90° shaft rotation in one second.

Leeds & Northrup 10260 Series

The unit shown in Fig. 4 is employed with the choice of proportional control with manual reset as single-action position-adjusting type (P.A.T.); or 3-action P.A.T.; or duration-adjusting type (D.A.T.) with proportional, reset, and rate modes of control. Fig. 1A shows its control bridges and feedback bridge circuit for proportional with manual reset. A dual bridge is used for proportional, reset and rate actions.

Frequency response of one drive unit in the 10260 Series, having 10-second full-travel time (with a Series-60 P.A.T. Controller) for input signals of ±5% and ±25% of full travel with proportional action only, is shown in Fig. 5. (Other models have full-travel time up to 60 seconds.)

The units feature self-locking worm-and-gear drives which stay in position on power failure. Remote control is exercised manually from the panel board by means of a simple control switch. Optional features available include auxiliary slide wires for (1) position

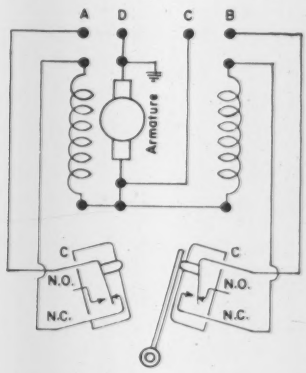
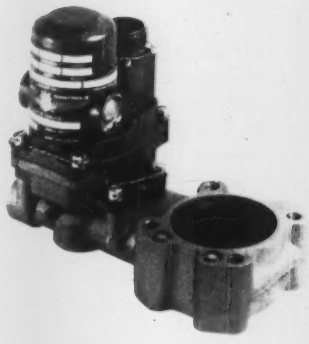


FIG. 3. TOP, schematic of General Control 1-second-response SD MA-11A1000A actuator, shown in closed position. Bottom, electric-motor-actuator on AV-10B valve.



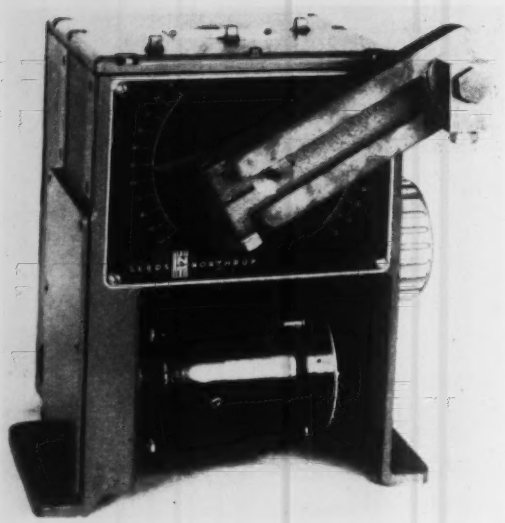


FIG. 4. **L&N** 10260 Series valve actuator.

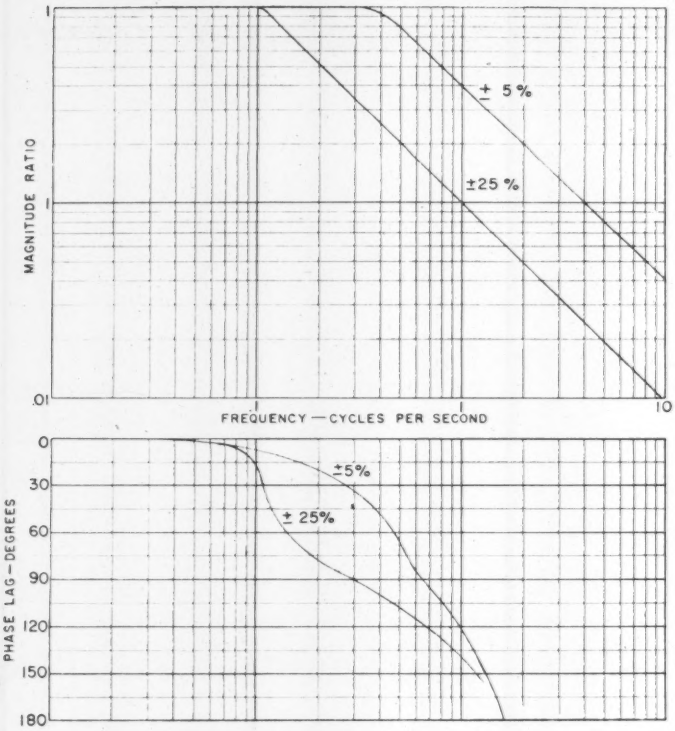
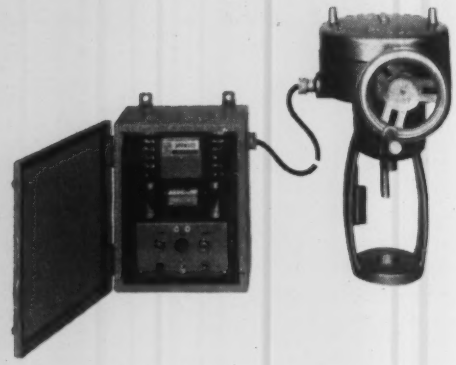


FIG. 5. FREQUENCY response of L&N 10260 Series drive unit and Series-60 P.A.T. controller with input signals for ± 5% and ± 25% of full output travel, proportional action only.

FIG. 6. NORWOOD all-electric positioner with thrust up to 1000 lb.



indication and (2) electric control systems and auxiliary limit switches. The position slidewires and limits are actuated directly from the output shaft. Drive units in the 10260 Series operate on 115-v, single-phase power supply. Units in the 11270 Series use 115- or 230-v, single-phase or 3-phase current, and can be supplied also for 440-v 3-phase operation or 125 vdc operation.

Input signal to the drive unit can be initiated from a two-position, a D.A.T., or a P.A.T. controller.

Torque output of the unit varies from 5 ft-lb (used with the D.A.T.) to 75 ft-lb in the 10260 series, and from 75 to 2500 ft-lb in the 11270 series.

Norwood Controls Model 1101

The all-electric positioner shown in Fig. 6 consists of an actuator (Model 1101) and an amplifier (Model 1150). It is capable of handling thrust loads up to 1000 lb in 4 seconds, and can achieve a stem speed of 0.15 in/sec. Input signal range may be 0 to 4 ma dc, 2 to 6 ma dc, or any intermediate range with the span of approximately 4 ma dc.

In the amplifier (Fig. 1C) a summing circuit compares the feedback signal from a stem-position potentiometer. In event of unbalance, a transistor amplifier passes the signal on to a three-position relay energizing a 1/40-hp 2-phase induction motor which moves the stem via a gear train and a ball-screw mechanism. A brake which is actuated when motor power is removed insures that the actuator will remain in its last position in event of power failure. Positioning repeatability of ±¼% is achieved by using a narrow dead zone and a transmission of high mechanical efficiency. The feedback potentiometer furnishes remote indication of actual stem position. Limit switches guard the two extremes of stem motion.

The response of the valve stem to small-amplitude sinusoidal input signals is determined by the motor acceleration capabilities, damping, and the size of the dead zone. With larger inputs, motor speed limiting governs the response.

For amplitude corresponding to 2% or less of the full output the amplitude-vs-frequency curve is flat up 1.0 cps. For 10% amplitude it is flat up to 0.5 cps.

Journal of the S C M A . . .

SOUTHERN CALIFORNIA METER ASSOCIATION

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LAHJC-SCMA INSTRUMENT SHORT COURSE

MARCH 26-27, 1959

TENTATIVE PROGRAM—
EIGHTH ANNUAL INSTRUMENT SHORT COURSE

SUBJECT	PROBABLE SPEAKER
Keynote Speaker	R. Rimbach, Instruments Publishing Co.
Panel Discussion—Electronic Control Systems	Shank, Walchli, Ferree, Pitt, Omwake, Anthony
Fundamentals of Measurement	
Flow Measurement	B. Artz of Fisher & Porter
Level Measurement	D. Matthews of Mason-Neilan
Pressure Measurement	Dr. Crane of Decker Engineering
Temperature Measurement	Schaaf, Dyer, and Sara of Taylor
Specific Gravity Measurement	J. Dunn, Jr. of Amer. Rec. Chart Co.
Orifice Meter Coefficients	Unassigned, Daniel Orifice Fitting Co
ISA Automatic Control film	V. Jones of Union Oil
Instruments	
Bellows Flow Meters	W. Reese of Industrial Instruments
Turbine Flowmeters	J. Muhleman of Waugh Engineering
Integrating Flowmeters	W. D. Straight of So. California Gas
Pneumatic Control	F. Blake of Honeywell
Electronic Control	H. Joseph of Swanson Engineering
Valve Actuators	C. Beard of General Controls
Applications	
Wide Range Flow Control	W. Masheter of So. Counties Gas
Pulsating Flow Measurement	Everett of Pulsation Control
Selection of Control Valve Pressure Drop	H. Simon of Fluor
Pressure Regulation of Gases	R. Lisk of Fisher Governor
Automatic Custody Transfer	W. Lacy of Black, Sivalls & Bryson
Capacitance Instrumentation Application	C. Carkeek of Carkeek Engineering
Advanced Techniques	
Radioactive Process Instruments	O. W. Graham of Instruments
Aircraft Flowmeter Calibration	H. Eichenberger of Convair
pH Control	R. Connor of Beckman
Chromatography & Process Control	Unassigned, CEC
Selection of Analytical Instruments	G. Turner of Beckman
ISA Frequency Response film	Unassigned

THE FORMIDABLE array of initials LAHJC-SCMA represents the joint efforts of two Southern California groups to promote the spread of instrument education. The Los Angeles Harbor Junior College (1111 Figueroa Street, Wilmington, California) is a state-owned public Junior College which offers various courses of study up through the sophomore year of college. The Southern California Meter Association is a technical society of nearly 600 members devoted to the futherance of technical knowledge in the field of instrumentation. It holds meetings the third Thursday of every month at the Rio Hondo Country Club, Downey, California. Technical talks presented at these meetings are published in the *Journal of the SCMA* in *Instruments and Control Systems* magazine.

These two organizations have successfully cooperated in presenting the Instrument Short Course, which is now in its eighth year. Each course has had the same general objective—to present, in a concentrated course of study, the basic principles and the latest advancements of measurement and control technology to the instrument technician and the instrument engineer.

Description

Running for two consecutive days, the Short Course is held during one of the school vacations to allow for full use of the school's facilities. Two main divisions are presented—the **General Sessions** and the **Practical Methods.** General Sessions consist of class lectures divided into four categories: Fundamentals of Measurement, Instruments, Applications, and Advanced Techniques. The first is presented for those new in the field, and as a refresher in basic principles. *Instruments* classes are each concerned with a specific piece of instrument equipment—what it is and how it works. Special problems of measurement and control are covered in the category called *Applications.* In *Advanced Techniques*, special attention is paid to the latest developments in measurement and control-analysis instruments, data-handling techniques, systems analysis, and so on (Fig. 1).

The *Practical Methods* division is devoted to the

FIG. 1.

FIG. 2.

instrument mechanic and his problems. Each man is offered a course of seven classes in which he may learn the application, maintenance and repair of specific instruments as taught by factory representatives. A certificate is awarded upon completion of six classes (Fig. 2).

In addition to these sessions, over 40 instrument manufacturers and local representatives each year exhibit the latest developments in their field during the two days the course is held.

The talks given at the *General Sessions* have produced many excellent technical papers, many of which have been published in the *Journal of the SCMA* in *Instruments and Control Systems*. (An appendix contains a list of the talks given over the last four years, with author's name and affiliation briefly indicated.)

The tentative program of the forthcoming Short Course to be given on March 26 and 27, 1959 is on page 249.

APPENDIX—PROGRAMS AT SHORT COURSE, SCMA—LAHJC, 1955-1958

	FUNDAMENTALS	MEASUREMENT
1958	Orifice Meter Measurement (Elayer—Richfield Oil) Regulation Pitfalls (Masheter—So. Counties Gas) Electro-Pneumatic & Electro-Hydraulic Valve Operators (Gilliland—MM&M) Liquid Level Measurement (Vossler—BS&B) Automatic Control Film (Jones—Union Oil) Force & Motion Balance Controllers (Thackara—Mason-Neilan) Temperature Measurement (Blake & Lisenby—Honeywell)	Flow Measurement Problems (Hill—Parsons) Bellows Type Orifice Gages (Parr—Foxboro) Orifice Meter Coefficients (Kennedy—So. California Gas) Specs for Orifice Meter Runs (Lange—So. California Gas) Unusual Flow Elements (Pitt—Foxboro) Available d/P Elements (Peatross—Taylor) Measurement of Variables in Liquid Storage (Long—Varec)
1957	Gas Displacement Meters (Donnelly—Rockwell) Orifice Meter Measurement (Kemp—So. California Gas) Pressure Regulation (Masheter—So. Counties Gas) Electro-Pneumatic Converters (Gilliland—MM&M) Instal. & Hook-Up of Orifice Gauges (Welch—General Petroleum) Automatic Control Film (Apel—Union Oil) Temperature Measurement (Corbin—Honeywell)	Force Balance Instruments (Waxman—Hagan) Unusual Measurement Problems (Parr—Foxboro) Bellows Type Orifice Gauges (Nolte—Barton) Design of Orifice Meter Runs (Wilson—Daniels) Differential Pressure Converters (Ziegler—Taylor) Maintenance of Orifice Gauges (Koepke—Union Oil) Meter Coefficients (Wood—Honolulu Oil)
1956	Orifice Meter Measurement (Nolte—Barton) Gas Displacement Meters (Donnelly—Rockwell) Pressure Regulation (Meyer—Carter-Jones) Film on Automatic Control (Koepke—Union Oil) New Electro-Pneumatic Control System (James—L&N) Specific Gravity (Adams—Signal Oil) Temperature Measurement—Expansion & Thermoelectric (Paull—Honeywell)	Remote Tank Gauging (Dickenson—Varec) Integrating Orifice Meters (Straight—So. California Gas) Bellows Type Orifice Meters (Christian—Barton) Rotameters (Brooks) (Pribble—Pribble Co.) Computation of Gas Coefficients (Lange—So. California Gas) Maintenance of Mercury Meters (Welch—General Petroleum) Problems of Field Measurement of Wet Gas (Stillson—Bushnell Controls)
1955	Orifice Meter Measurement (Nolte—Barton) Principles of Auto Control (Rogers—Foxboro) Force Balance Principles (Jones—Moore Products) Fundamentals of Electronic Controllers (Gates—MM&M) Ranarex Gas Gravitometer (Quirk—Now Robertshaw-Fulton) Principles of Temperature Measurement (Paull—Honeywell)	Natural Gas Calorimetry (Cossey—So. California Gas) Orifice Meter Coefficients (Lange—So. California Gas) Orsat Gas Analysis (Vincent—P.L.G.S.) Measurement of Liquids with Orifice Meters (Voils—General Petroleum) Testing Positive Displacement Meters (Campbell—American Meter) Bellows Type Orifice Meters (Christian—Barton) Problems of Field Gas Measurement (Atkinson—American Meter) Variable Area Meters (Nute—Meriam Co.) Maintenance of Differential Pressure Gauges (Adams—Monterey Oil) Electronic Temperature Measurement (Ferree—Honeywell)

S.C.M.A. HANDBOOK

SECTION INDEX

Title	Section
Gas Flow—General	1
Gas Flow—Flange Taps	2
Gas Flow—Pipe Taps	3
Steam Flow	4
Liquid Flow	5
Displacement Meters	6
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Flange and Piping Data	8
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The handbook sells for $7.50 to members of the Association and $10.00 to non-members. Inquiries should be directed to the Secretary of the S.C.M.A. Revisions and additions are made periodically.

PAST PRESIDENTS OF THE SCMA

Year served and company affiliation

1—1927-1928	T. K. M. Smith*	Pacific Lighting Gas Supply Co. (retired)
2—1928-1929	B. M. Laulhere	Deceased (Southern California Gas Co.)
3—1929-1930	J. J. Delaney	Deceased (Reliance Regulator Div.)
4—1929-1930	R. F. Angell	Union Oil Company of California
5—1930-1931	B. G. Williams	Deceased (Southern California Gas Co.)
6—1931-1932	P. W. Hill	Signal Oil & Gas Company
7—1932-1933	L. P. W. DesBrisay*	Southern California Gas Co. (retired)
8—1933-1934	C. B. Heartwell	Standard Oil Company of California
9—1934-1935	Edgar Wilde*	Southern Counties Gas Company (retired
10—1935-1936	F. E. Bradley	Coline Gasoline Corporation
11—1936-1937	H. A. Faull	Now in private business in Pomona
12—1937-1938	J. B. Taylor, Jr.	Signal Oil & Gas Company
13—1938-1939	Guy Corfield	Southern California Gas Company
14—1939-1940	Geo. H. Forster, Jr.	The Texas Company
15—1940-1941	M. J. Cereghino	Retired—now living in Whittier
16—1941-1942	W. H. Williams	The Fluor Corporation, Ltd.
17—1942-1943	W. L. Cowan*	Union Oil Co. of California (retired)
18—1943-1944	J. T. Cortelyou	Southern California Gas Company
19—1944-1945	Mark McIlvaine	Deceased (C. W. O. D. Company)
19—Honorary	Ross T. Furlong	The Texas Company
20—1945-1946	C. L. Hutchings	Tidewater Oil Company
21—1946-1947	Lee Cheever	Southern Counties Gas Company
22—1947-1948	C. G. Cortelyou	General Petroleum Corporation
23—1948-1949	J. C. Groenewegen	Shell Chemical Corporation
24—1949-1950	R. Frank Fields	Southern California Gas Company
24—Honorary	Edgar Valby	Richfield Oil Corporation
25—1950-1951	James E. Adams	Signal Oil & Gas Company
26—1951-1952	H. C. Bennett	Southern California Edison Company
27—1952-1953	F. M. Partridge	Pacific Northwest Pipeline Corporation
28—1953-1954	James A. Serey	Signal-Hancock Corporation
29—1954-1955	Glen C. Wilson	Southern California Gas Company
30—1955-1956	Glen C. Gallagher	The Fluor Corporation, Ltd.
31—1956-1957	Philip Ver Planck, Jr.	Pacific Lighting Gas Supply Company
32—1957-1958	Richmond M. Voils, Jr.	General Petroleum Corporation

*Life Membership extended upon retirement.

Other Life Members:

Gordon S. Duncan	General Petroleum Corporation (retired)
J. A. Gendron	Southern California Gas Company (retired)

APPLICATION PROBLEMS

Sizing of Control Valves (Myers—B. R. Jones Co.)
Expansible Tube Regulators (Wehrman—Grove Regulator)
Use of Relief Valves (Dietzman—Parsons)
Continuous Product Blending (Wimpress—Braun)
Controls for Valve Operators (Ledeen—Ledeen Mfg.)
Liquid Level Control (Maire—B. R. Jones Co.)
Electronic Controllers (Anthony—Swartwout)

Flow Tubes (Hennessy—B.I.F. Pacific)
Expansible Tube Type Regulators (Wehrman—Grove Regulator)
Gas Gravitometers (Gay—Amer. Rec. Chart)
Maintenance of Control Valves (Beard—General Controls)
Valve Power Operators (Altorfer—Shaffer Valve)
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Electronic Control Applications (Ferree—Honeywell)

Viscosimeters (Peuser—Jensen Instruments)
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Ranarex Gas Gravitometers (Quirk—Fluor)
Maintenance of Diaphragm Control Valves
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(Galley—Engr. Cons.)
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Safety Valve Selection (Conison—Parsons)
Install Orifice Meter Stations (Norman—So. California Gas)
Displacement Meters—Oils, Liquids (Clark—Rockwell)
Manometer Applications (Meriam—Meriam Co.)
Selection of Control Valves (Matthews—Mason-Neilan)
Maintenance of Regulators (Delaney—American Meter)
Continuous Accumulation of Gas Samples
(Curtin—So. California Gas)
Panel on Regulation & Control (Reps-So. Counties Gas and others)

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Gas Chromatography & Process Problems (Johns—Beckman)
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Chromatographic Inst. (Walters—California Research)
Radiation Type Level Indicator (Foy—Crown Engineering)
Telemetering (Head—Control Corp.)
Data Handling (Leary—Braun)
Computer Applications (Ramo-Wooldridge)

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Infrared Spectrophotometer (Loe—Perken-Elmer)
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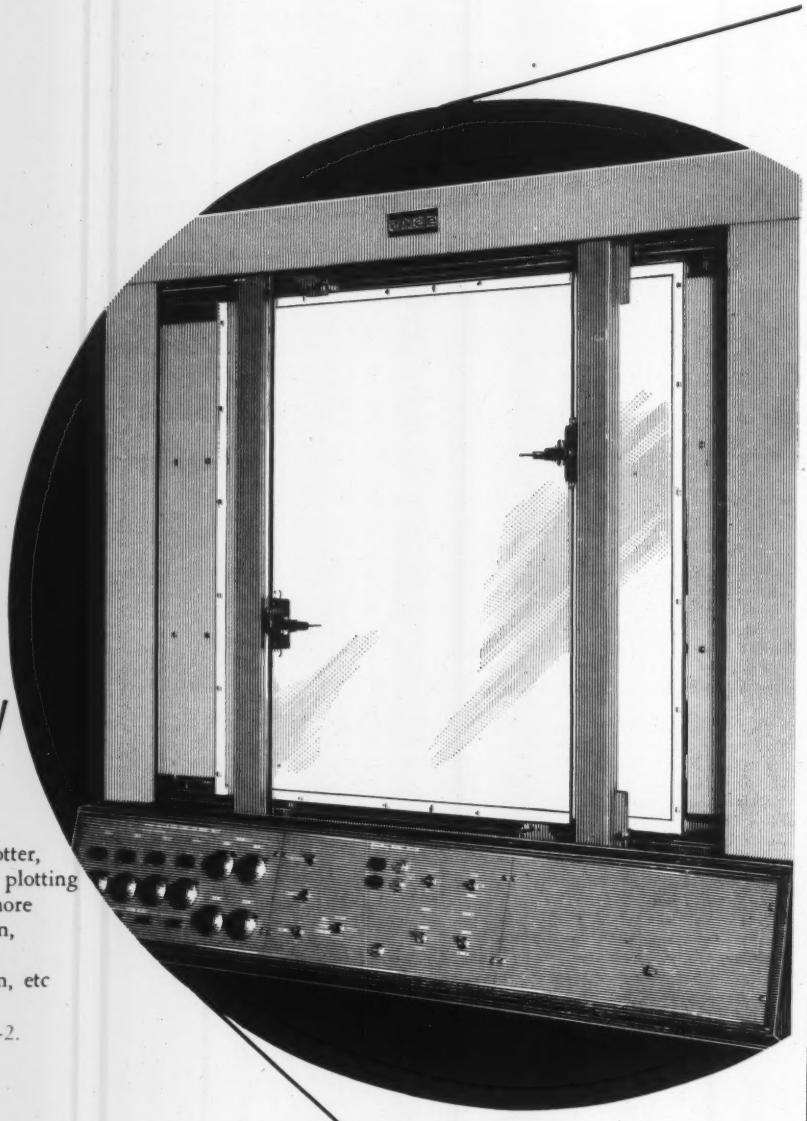

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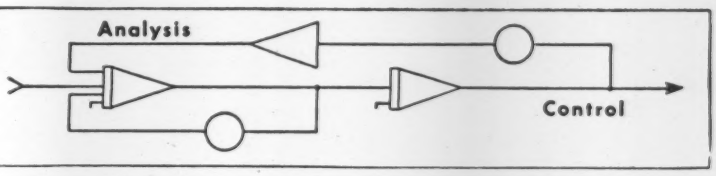

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Bits

This month we complete the story of the November meeting of the Western Simulation Council (the first paper was reported in last month's Newsletter) by presenting a shortened version of a talk by W. J. Karplus on "Simulation of Field Problems" and some information given us by C. T. Leondes on the Western Data Processing Center at UCLA.

To bring you somewhat more up-to-date on our activities we also report on Gene Grabbe's talk about his trip to Russia, which was presented at the January meeting of the Western Simulation Council. The second part of that meeting, at which Max Palevsky and Ed DeLand gave impressions gained when they attended the Strasbourg conference on analog computers, and the third part, at which the Western Simulation Council tried individual discussion groups for the first time, will be reported next month.

Pieces

WESTERN S/C MEETING OF NOVEMBER 20 ON "SIMULATION OF FIELD PROBLEMS"

Dr. W. J. Karplus (University of California, Los Angeles) was the second speaker at the 20 November 1958 meeting of the Western Simulation Council, held at UCLA.

Karplus on "Simulation of Field Problems"

Dr. Karplus, referring to Kovach's talk on Simulation of Field Problems, said: "The previous talk included an excellent summary of the conventional RC analog method for simulating transient heat transfer problems.

Two years ago a new and radically different network analyzer method for treating problems similar to those discussed by Dr. Kovach was introduced by Liebmann in England.* In this method the network analog consists of resistors only. No capacitors are required to simulate fields governed by the equation

$$\nabla^2\phi = k\,(\partial\phi/\partial t) \qquad (1)$$

Since such fields contain two of the three basic parameter types (energy dissipators and potential-energy reservoirs or kinetic-energy reservoirs), resistance-reactance networks are generally employed as the analog model. Liebmann's technique is based on the complete finite-difference expansion of Equation 1. For fields in one space dimension

$$\frac{\phi_1-\phi_0}{\Delta x^2}+\frac{\phi_2-\phi_0}{\Delta x^2}\cong R\,\frac{\phi_0-\phi_{t0}-\Delta t}{\Delta t} \qquad (2)$$

"Note that the Laplacian as well as the time derivative has been discretized and that the backward-difference approximation is employed for the time function. The node equation for the analogous resistance network is

$$\frac{V_1-V_0}{R_x}+\frac{V_2-V_0}{R_x}=\frac{V_0-V_{t0}-\Delta t}{R_t} \qquad (3)$$

as illustrated in Figure 1. This network permits prediction of the potential at all nodes at a time $t = t_o + \Delta t$ if the potentials at time $t = t_o$ are known. To solve a typical problem, the resistors R_t are made proportional to a convenient Δt, and the given initial voltages at time $t = 0$ are applied at their lower terminals. The potentials at time $t_o+\Delta t$ are then obtained by measuring the voltages at the network nodes. The feed-in voltages to all feed-in resistors are then readjusted to correspond to the network voltages for time $t = t_o+\Delta t$. The voltages now appearing at the network nodes correspond to the potentials at time $t = t_o+2\Delta t$. The feed-in voltages are again adjusted, and the process continued until the potentials cor-

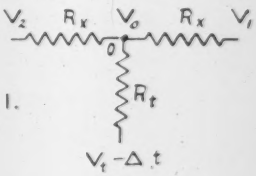


Fig. 1.

*G. Liebmann, *A New Electrical Analog Method for the Solution of Transient Heat Conductor Problems*, Transactions of the ASME, Vol. 78, pp 655-665, 1956.

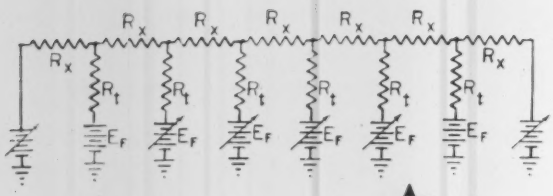


Fig. 2

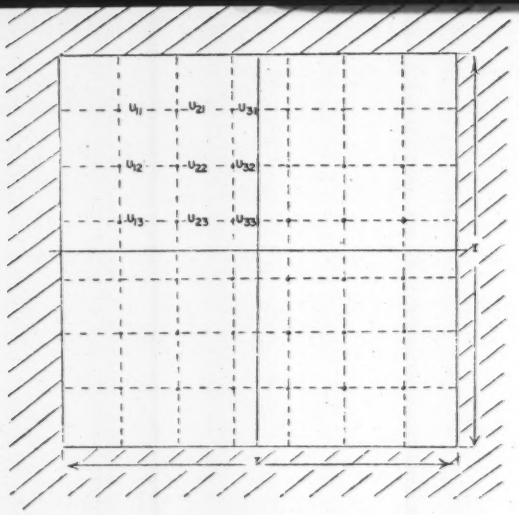


Fig. 3

responding to the desired number of time intervals have been obtained. It can be shown that there is no possibility of computational instability if Equation 2 is simulated, so that $\Delta t/\Delta x^2$ may be made as large as desired.

"The complete one-dimensional system is shown in Figure 2, while more convenient circuits are described in Liebmann's paper. This method is also applicable to two- and three-dimensional systems, fields with non-uniform properties, and fields with transient excitations. A more detailed discussion of this method is presented in Dr. Karplus' book *Analog Simulation* (McGraw-Hill, 1958).

"The research laboratory of Associated Electrical Industries, Ltd. has developed a special-purpose analog simulator along the foregoing lines for the British Admiralty. It constitutes an advance over Liebmann's basic method in that it contains facilities for the automatic application of the feed-in voltages and the recording of potentials of all mesh points as the solution proceeds. It is equipped to handle 200 mesh points and has provisions for an extension to 400 mesh points. Initial conditions—that is, the voltages assigned to the lower ends of the feed-in resistors at the start of the problem—are set on potentiometers by means of hand switches. A large dial is provided so that these can be checked visually as the network is traversed.

"The sensing of the node voltages is accomplished by means of potentiometers. Two potentiometers are provided for each node. The potentiometer wires are mounted on drums, controlled by servomechanisms, in such a way that the voltages at the network nodes are automatically and sequentially balanced against the voltages on the drums. When the end of a traverse is reached, the computer automatically places these voltages at the lower ends of the feed-in resistors, so that they may be used as "initial conditions" for the next step in time, and the second set of potentiometers is brought into action for the subsequent balancing operation. After this the roles of the two sets of potentiometers are interchanged. As each mesh point is balanced, the node voltage is fed to an output circuit which actuates a typewriter and automatically prints out the voltage magnitude and polarity. At the beginning of each traverse the typewriter records the serial number of the step and the identity of the set of potentiometers currently being used for balancing. Thus the printed page finally contains the distribution of potentials in the network as a function both of time and of space.

"As an example of the application of this method, consider the uniform two-dimensional field shown in Figure 3. Assume that the temperature distribution is initially uniform and that the boundary potentials are all made zero at time $t = 0$. The problem is to find the temperature transients for $t>0$. A finite difference grid is superimposed on the field. Taking advantage of symmetry, only one-half of the field is simulated (an additional simplification is possible if the symmetry about the main diagonals is recognized). The resistance network shown in Figure 4 is employed to simulate the Laplacian term $\nabla^2\phi$. At each of the nodes of this network a current is introduced by the analog computer circuit shown in Figure 5. The units shown in Figure 5 correspond to the feed-in voltage sources mentioned above. The solution now proceeds in a stepwise manner in time. The results of the computation are tabulated for several time increments in Table I.

"At UCLA they are currently working on extensions and refinements of this method; in particular they are applying it to problems governed by the wave equation (nonsteady state) and the biharmonic equation governing beam problems. From all indications, Liebmann's method appears to be a powerful new approach deserving of greater interest and utilization."

* * *

Following the Karplus talk, *Steve Paine* (Convair, San Diego, Calif.),

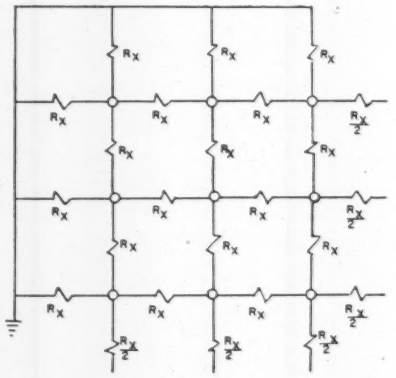


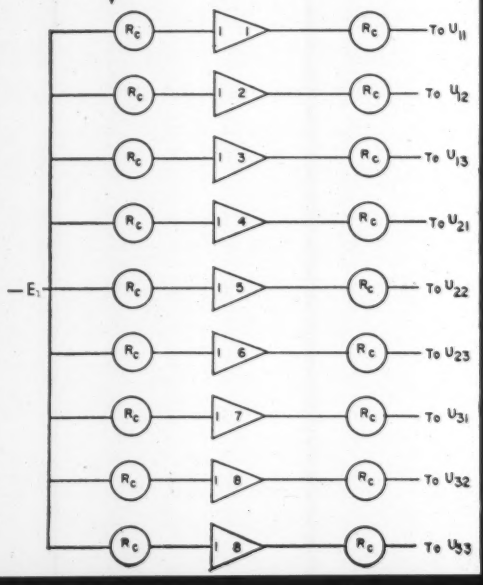
Fig. 4

TABLE 1—NODE VOLTAGE READINGS

(in Volts) vs Time (in Seconds)

Time (Sec)	U_{11}	U_{12}	U_{13}	U_{21}	U_{22}	U_{23}	U_{31}	U_{32}	U_{33}
0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
.1	15.0	19.5	20.7	19.5	26.6	28.0	20.8	28.0	29.4
.2	8.7	13.5	15.1	13.6	21.0	23.7	15.1	23.6	21.0
.3	6.3	10.2	11.9	10.2	17.0	20.0	11.9	20.0	23.6
.4	4.6	7.8	9.6	7.8	13.8	16.7	9.7	16.8	20.1
.5	3.6	6.5	7.8	6.6	11.3	13.8	7.6	13.8	17.0
.6	2.8	5.1	6.5	5.2	9.3	11.4	6.5	11.4	14.1
.7	2.4	4.2	5.2	4.2	7.6	9.5	5.2	9.6	11.7
.8	1.9	3.6	4.3	3.6	6.3	7.8	4.3	7.8	9.8
.9	1.6	2.8	3.6	2.8	5.1	6.5	3.6	6.5	8.1

Fig. 5



SPEAKING WITH EASE®

An up-to-the-minute report on computer technology prepared by the **Beckman/Berkeley** *engineering staff*

How to Solve More Problems in Less Time

How Much Time Does a Computer Spend Computing?

As analog computing problems become more complex, more time is spent setting up and checking the electrical analog, and less time actually generating solutions. When we consider that actual computation sometimes occupies less than 1% of total computer time, it becomes evident that any method of speeding up or eliminating set-up and check-out tasks offers immense rewards —either by expanding problem-handling capacity or reducing the size and cost of an adequate installation. This month we wish to acquaint you with some of the time-saving techniques which have become practical with the introduction of digital control units.

A Device for Reducing "Non-Computational" Time

The EASE digital control unit, nicknamed the "DO/IT" system, is more formally known as the "digital output/input translator." Because we know it best and because we believe it excels in general utility, we will talk about ways of using the DO/IT. A number of the techniques are applicable to other digital control systems.

In case you are unfamiliar with the DO/IT, it is a mechanism for entering and retrieving information via typewriter and punched tape. Its essentials are a Flexowriter coupled to the computer through a battery of telephone-type relays. The relays actuate a digital-to-analog converter which, in turn, drives a servo-set potentiometer system. The DO/IT is capable of entering coefficient pot settings, commanding the computer to assume any operational state, and reading out values at any or all points in the problem-solving circuit. Although designed for EASE computers, the DO/IT will operate with other analog equipment.

Keeping this in mind, let us point out some of the techniques that have proved to be enormous time-savers at our Los Angeles Computation Center.

Eliminate Pot Set Error

The trick is to screen out errors before approaching the computer. A punched tape and typewritten record of pot addresses and desired coefficients is prepared in advance on a Flexowriter. This is checked and errors are corrected before entry. How about errors in the servo setting? These are more unlikely, but to insure that they do not occur undetected, the DO/IT prints out the actual setting after each command and conscientiously prints the setting in *red* if it deviates more than 20mv from the command value.

Locate Errors Quickly

"Debugging" the computer (that is, checking the electrical analog to be sure it corresponds to the equations being solved) is often a lengthy and tedious procedure. Errors in mechanization and patching are easy to make and sometimes difficult to locate. The best procedure is to calculate the value of selected variables under one or two static conditions, then test the computer to see if correct voltages appear.

For example, EASE 1100 Series computers have an operating condition known as "Static Check." In this condition the problem-solving circuit is connected exactly as at the beginning of a computing run except that suitable voltages are substituted for the output of each integrator. Theoretical values under these conditions are calculated in advance from equations or from mechanization diagrams. The calculated values are entered on a punched tape together with instructions to compare these values with those existing in the computer. The DO/IT makes the comparison: if calculated and actual values agree, it prints nothing; if there is a discrepancy, it prints the difference. An operator, scanning the printed record, can immediately pinpoint errors in patching and mechanization – in addition to errors created by possible faulty components. As an added insurance against error, this test may be supplemented by a similar check under initial conditions and a check made after an arbitrary computing time under "hold" condition.

Because automatic scanning and printout makes it easy to check a problem set-up, operating personnel are inclined to make frequent tests. These tests often expose errors which would cost hours or days of computer time if undetected.

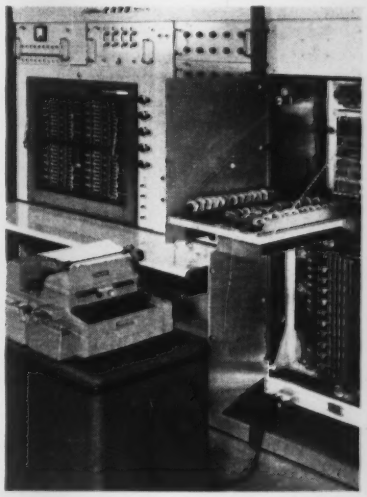
Program Survey Problems Automatically

In survey problems, equations remain essentially the same while a few parameters are changed from run to run. Solution of these problems can be speeded up by programing parameter changes on punched tape so that an entire series of computions will be run and recorded in rapid succession.

Run Two Problems "Simultaneously"

Problem handling capacity can be effectively doubled if two shifts of workers can use the same computer. Often this is impractical because one shift does not wish to destroy the set-up left by the previous crew, nor are they well enough acquainted with the problem to proceed with its solution. Punched tape entry and retrieval offer a way out of this dilemma. Each crew works on a separate problem. At the end of a shift, the people quitting work simply record all settings on punched tape and pull out the patchboard. Those coming on shift insert another patchboard and enter the previous day's setting via punched tape. In this way two projects can proceed simultaneously and without interference.

Write for further information on the DO/IT system, or better yet, see it in operation at our Los Angeles Computation Center, 305 Parkman Ave., Los Angeles 26. Kenneth Tuttle, Director.



The EASE digital control system, showing sturdy telephone-type relays which link flexowriter to digital-to-analog converter behind top panel.

C6

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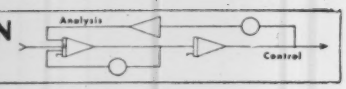

who had been industriously taking notes (and evidently thinking, as Steve is wont to do) was moved to comment somewhat as follows:

"I certainly agree with Dr. Kovach: analog computers can hold their own with respect to the digital computers. They depreciate slowly and can be operated at a fraction of the cost of a digital computer. Our DAEAC* operates at $7.50 per hour (not counting depreciation) versus $350.00 per hour for the IBM 704. Set-up time is short and changes in parameters and geometry are easy to instrument.

"I would also like to add yet another reference to Professor Karplus' bibliography. Just a few months ago a translation of Professor Cauer's book *Synthesis of Linear Communication Network* was published by McGraw-Hill. This brilliant exposition will provide those interested in simulation with some of the most sophisticated circuits and analysis yet developed.

"Finally, I am pleased to see Professor Karplus pay such careful attention to error analysis** in deriving the necessary approximation formulae for his field simulations. In this age of high-speed computers, floating point approximations, and little accompanying error analysis, it is comforting to see analog-computer people stepping forward to aid the few people, like Richmyer and our friend Juncosa at Rand Corporation, who are concerned about the propagation of errors in the solution of field problems. I think this is an area in which we should become active."

Leondes on WDPC

C. T. Leondes (UCLA), who was the next speaker at the WS/C meeting of Nov. 20, had been asked to give us some information on the Western Data Processing Center at UCLA.

It seems that the WDPC, established in November of '56, is the nation's first university computing center organized specifically to support education and research in the field of business data processing.

Basic support comes from funds appropriated by the Regents of the University and from a generous grant of the International Business Machines Corporation. These two sources provide operating funds and a building to house the Center on the UCLA campus. IBM has further provided free use of data-processing machines and substantial funds for IBM Research Assistant and Research Associate appointments.

The WDPC serves not only UCLA but universities and colleges located in the eleven Western states and Hawaii. Participating institutions have the right to utilize facilities of the Center without charge and to take part in educational and research programs offered by the Center.

Major objective of the WDPC is education and research in business and data processing. It attempts to meet this objective in two ways: first, by stimulating interest in the general field of electronic data processing among faculty members and students in schools of business administration at UCLA and participating institutions; and second, by undertaking as much of a program of education and research as available personnel and facilities will permit.

Since April of 1957 the WDPC has operated a machine installation consisting of an IBM 650 and various auxiliary punched-card machines, housed in 1800 square feet of the Business Administration and Economics Building. With this full range of punched-card machines the Center has furnished complete tabulating and data processing services to the 100 or so projects that have utilized the equipment during 1957 and to date.

In the middle of July, 1958, the Center moved to a building of 15,000 square feet which houses the Center's permanent machine installations. The major piece of equipment here is an IBM type 709 electronic data-processing machine which has been called the most powerful computer commercially available.

* * *

Next came a coffee break (don't know yet who paid for the refreshments, but some people sure looked embarrassed), and then a tour (better described as an extended hike*) to see the Bush-type mechanical analog computer in action (a wondrous thing to see *and* hear) and the 709 so inanimate by comparison that it was deemed necessary to adorn the walls of their new modernistic building with garish finger paintings to keep personnel awake). Very impressive!

*At Convair-Fort Worth

**Seems ye Ed missed something!

WESTERN S/C MEETING OF JAN 8 ON "EUROPEAN COMPUTERS"

The January 8th meeting of the Western Simulation Council, with its program on "Computer Developments in Europe", attracted more than 50 representatives of 25 organizations to the Northrop Aircraft plant in Hawthorne, California.

Grabbe on Russian Developments

Eugene Grabbe (Thompson Ramo Wooldridge Inc., Los Angeles) the first speaker, travelled in the USSR as member of an exchange delegation sponsored by the American Automatic Control Council. Gene said they visited 12 or 13 plants and that the Russians answered all questions—apparently honestly. Asked what made the "honesty" apparent, he explained that different members of his group asked the same question of different Russians, and the same questions in different ways, and were unable to uncover any discrepancies.

He showed pictures of Russian computers and, on the human interest side, some street scenes including people. One picture showed Gene talking to three Russian high-school-age boys; he commented that because of their language training the boys could and would speak English as long as he would talk to them. They were very curious about life in the U.S. and how their counterparts here live, what they do, what they study, etc., etc.

The information Gene gave us on Russian computers was essentially the same as that contained in notes on his presentation to the Los Angeles Chapter of the Association for Computing Machinery (made the previous evening) so we quote from them directly:

"A variety of computers have been designed and constructed in the U. S. S. R. at different technical institutes. Available data on digital machines is given in the attached table. So far applications have been exclusively to scientific and engineering problems. At present, there are about 400 electronic digital computers in operation in the U. S. S. R. The URAL is the only computer known to be in production. The selling price of the URAL, which is comparable to an IBM 650, is 800,000

*It only incidentally included all of the rest of the campus.

rubles or $200,000 at the official exchange rate of 4 rubles per dollar. The STRELA (15 produced) sold for 5 million rubles or about $1 million. Calculated at the tourist rate of exchange, 10 rubles per dollar, these figures would be $80,000 and $500,000, respectively.

"On the basis of average speed, the Russians estimate that their STRELA computer is similar to an IBM 701 or about half as effective as an IBM 704. A new unnamed machine, currently under design, will be four times as fast as the 704 for scientific and engineering problems. The new Soviet machine will have 10,000 transistors (alloy transistors will be used) and 25,000-30,000 diodes. These figures include input and output equipment. The input will be punched paper tape to magnetic tape and output will utilize a 1,200 line-per-minute printer. An experimental model of the new machine will be completed early in 1959. Different machines in the Soviet Union have used 6.5, 16, 25, 36, and 125 mm magnetic tape (¼", 3/5", 1", 1-2/5", and 5"). It was stated that new machines will standardize on 25 or 36 mm tape.

"The new Soviet machine will use magnetic core storage with 6-microsecond access time. The core speed for the STRELA was 4.5 microseconds. The slower core speed is used because it is felt that it is more economical and has higher reliability. In most computers, two cores per digit are used for storage. In the SETUN machine, one ternary digit is stored in two cores.

Experience with the Soviet computers indicates that vacuum tubes are good for about 10,000 hours of operation. Transistors in the U.S.S.R. are said to be guaranteed by the manufacturers for 5,000-10,000 hours of operation. The URAL and KIEV are represented to be serial machines and the others parallel. Input and storage vary so that many machines are serial-parallel combinations.

"BESM I was designed by S. A. Lebedev of the Institute of Exact Machines and Computing Techniques (IEMCT), Academy of Sciences, U.S.S.R. The original model used cathode ray storage but this has been replaced by core storage with 6 μsec. access time. BESM I used vacuum diodes which are listed in the table as tubes. In BESM II, semiconductor diodes are employed. These machines compute during tape search and employ a photoprinter for output.

CHARACTERISTICS OF RUSSIAN COMPUTERS

	BESM I/II	STRELA I/II	M-2	URAL	SETUN	KIEV
Completion Date	1953	1953	1954	1955	1959?	1959?
Units	2	15	17	> 300	1	1
Numbers:						
Base	2	2, 10	2	2	3	2
Length	39	43, 14	34	36	18	41
Radix Point	Floating	Floating	Floating, Fixed	Fixed	Fixed	Fixed
Triad	(32, 5, 0)	(36, 6, 0) (9, 5, 0)	(28, 6, 0) (34, 0, 0)	(36,0,0)	(18,0,0)	(41,0,0)
Instructions:						
Per word	1	1	1	2	2	1
Addresses	3	3	3	1	1	3
Number	31	28	30	29	27	20
Pentad	(11, 11, 11, 1, 5)	(12, 12, 12, 1, 6)	(10, 10, 10, 0, 4)			
Storage (words):						
Cores	1000/2000	2048	512CRT		81	
Drums	5120		512	1028	2000	(3)4000(RZ)
Tapes	(4) 30,000	(4)200,000	50,000			(3)40,000
Input*-Output + (channels):						
Punched cards		1-O	400 char.		1	
Punched tape	20 words /sec (2)*	1-O	/sec.*/	300 words /min (2) +	400 char. /sec (5) +	
Punched film				35 words /sec (11) *		40 words /sec *
Mag. tape	400(2)* +					
Printer	200 words /sec*(photo)			100 words /min +	O	
Speeds:						
Oper./sec.	8-10,000	2-3,000	2-3,000	1000	?	5000
Pulse rate				286 kc	200 kc	no clock
Mult. time	270μ sec.	500μ sec.		10 ms	360μ sec.	200μ sec.
Add. time	77μ sec.			10 ms	180μ sec.	
Drum rpm:	750			600	7000	
Tracks/diam.				18/6"	60/4"	84/
Density	200 bits/in			100 bits/in		
Core Access	6μ sec.	4.5μ sec.				10μ sec.
Magnetic Tape:						
Width/channels	6 5mm/2	4"/43		6.5mm?		
Components:						
Tubes/diodes	(I)7000/0 (II)5000/?	(I)8000/ 55,000 (II)Trans.	1700/?	800/3000	20/? + cores + trans.	2000/?

ABBREVIATIONS.—Number triad: (m, n, p) m = mantissa length, n = exponent length, p = digits to left of radix point, n = 0 means fixed point, p = 0 means numbers have absolute value less than 1. Instruction pentad: (1st address length, 2nd address length, 3rd address length, special normalization or breakpoint digits, and operation digit length), Σ pentad = instruction length.

ARE any new fields of computation opened up by the GPS High Speed Analog Computer?

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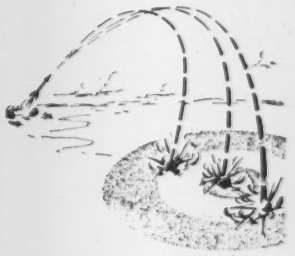

high speed computer such that the solution is carried out several thousand times faster than real time, samples of a random variable such as the miss distance of a missile system can be taken at rates up to 50 per second. Thus, sample sizes of several hundred can be taken in a few seconds' time.

GPS has a complete line of equipment to generate random noise for introduction to the system and to monitor the output. RMS values of random variables can be measured directly and complete probability distribution functions can be determined with statistical confidence in a matter of minutes.

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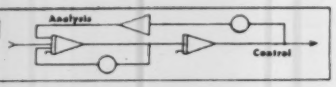
For more information circle **68** on inquiry card.



"The URAL was built by the Institute of Machines and Instrument Design, designed by J. Basileveski. Words are stored in a parallel series fashion on the drum. Eighteen heads read two drum slots to obtain a word. The punched film is standard 35-mm film and uses a photoelectric reader. The URAL has a compiler for symbolic language.

"The STRELA was designed by N. Brusentsov, IEMCT, Academy of Sciences, U.S.S.R. The machine has built-in subroutines and a larger-scale compiler. Production of this machine is said to have been curtailed to wait for an advanced model. The STRELA, at the Moscow Computing Center, is said to have a ten-minute mean free time between errors.

"The KIEV computer is under construction at the Ukrainian Technical Institute at Kiev for calculations in the chemical, metallurgical, and oil refining industries. This machine has built-in binary to decimal, decimal to binary conversion. It does not have built-in division. The drum is addressable by blocks or by individual words.

"The M-2 computer was built at the Energetics Institute, Academy of Sciences, for computing problems in the electrical power systems in the European section of the U.S.S.R. This machine has a subroutine library on magnetic tapes.

"SETUN is an experimental machine under construction at Moscow State University. It is named for a creek that runs by the university. It uses an iterative subroutine in place of built-in division. Circuitry consists of mag-amps using ferrite cores which operate at 200 kc. Attention has been given to miniaturization. Drum reading amplifiers use transistors. A single unit containing one record tube and a five transistor read-amplifier can be switched to any one of three tracks on the drum. The SETUN is said to be constructed because of dissatisfaction with the STRELA.

"Other machines that have been built in the Soviet Union (Power Engineering Institute) include the M-3, which has 805 tubes, a 248-word drum storage, and 1,800 operations per second. The MESM is a three address machine, having 40 commands, a 31 digit word and 2,000 tubes. It was built at the Ukrainian Academy of Sciences in 1951. The KRISTALL is a slow machine built for use in chemical research and crystal structure determination. It does 200 operations per second, has 440 tubes and 10,000 parts.

"The Russians have made extensive use of analog computers in engineering work. Many of these are special-purpose machines designed for solving differential equations of specific types. Others are general-purpose machines of modular construction. For example, one early model had three types of modules: multiplication by constants, amplifiers, and variable coefficient amplifiers using step switches. This is d-c equipment without chopper stabilization. About 1,000 installations of varying size are in use.

"A typical special purpose analog computer is Model MN-M, a transistorized machine developed in 1955 for solving sixth order equations. This equipment is housed in a case about the size of a small trunk. It has six function generators, using silicon diodes, four thyrite multipliers, and 18 amplifiers. About 300 of these computers are now in use. On the basis of sample figures obtained on usage, it is quite likely that there are some four or five thousand analog computer installations in the Soviet Union."

References

1. S. A. Lebedev, "The High-Speed Electronic Calculating Machine (BESM) of the Academy of Sciences of the U.S.S.R." (In English), J.A.C.M., Vol. 3, No. 3, July 1956, pp. 129-133.
2. IU. IA. Bazilevskii, "The Universal Electronic Digital Machine (URAL) for Engineering Research," (In English), J.A.C.M., Vol. 4, No. 4, October 1957, pp. 511-519.
3. Proceedings of the Computer Conference held in Moscow, 7-12 March 1956, Vol. 1, "Paths of Development of Soviet Mathematical Mechanization and Instrumentation;" Vol. 2, "Universal Digital Machines" (In Russian).
4. Unpublished notes of Prof. James E. Robertson, Digital Computer Laboratory, University of Illinois, on Visit to the Soviet Union, August 27-September 10, 1958.
5. V. B. Ushakov, editor of catalog, "Electronic Computing Machines; Instruments for Ultrashort Frequencies," Central Bureau of Technical Information on Instruments and Automation, (no date), 75 pp.
6. "A Team Reports on Control Inside Russia," Control Engineering, Nov., 1958.

Gene said the Russians were friendly, very friendly* in fact. After toasting in vodka everyone from Khrushchev to the Americans' children—individually—one of them said, "You Americans are such good fellows; why is it your politicians are so stupid?"

Information

We have a 7-page progress report on the Digital Computer Laboratory of the University of Denver. Gist is:

1. They are coming along OK.
2. Present usage is about 60% of first shift and 40% of second.
3. They would like full usage.
4. The services of the lab are commercially available under three plans, one of which should satisfy most any user's requirements.

★ ★ ★

*We know a female oceanographer who recently spent an evening with a friendly Russian scientist. She says it was like dating an octopus!—ED.

The Association Internationale pour le Calcul Analogique announces that the proceedings of the "Secondes Journees de Calcul Analogique" (held at Strasbourg 1-6 September 1958) are now available. Orders should be sent to the Association at 50, avenue Franklin D. Roosevelt, Bruxelles, Belgium.

★ ★ ★

The IRE is calling for papers for their National Automatic Control Conference, to be held 4-6 November 1959 in the Sheraton Hotel, Dallas.

★ ★ ★

A colleague of your Editor's, Herb Salzer, has, like other mathematicians before him, invented an international language, in this instance "Geo." Herb will send anyone interested a detailed explanation for two bits.* However, the aspect which might be of interest to digital computer or machine translation people is that if all the rules for writing and translating Geo were followed except that machine numbers were substituted for the 700 words in the simplified vocabulary, inter-language translation largely by machine would be possible.

He Went–Up

We are pleased to learn that another charter member of the original Simulation Council, the Western, has received another promotion: *Romeo Favreau* is now a Vice-President of Electronic Associates, Inc.

Computer Events

Western Joint Computer Conference

Dates: 3-5 March 1959
Place: San Francisco, Calif.

Southwest IRE Regional Conference and Electronics Show

Dates: 16-18 April 1959

Place: Dallas, Texas

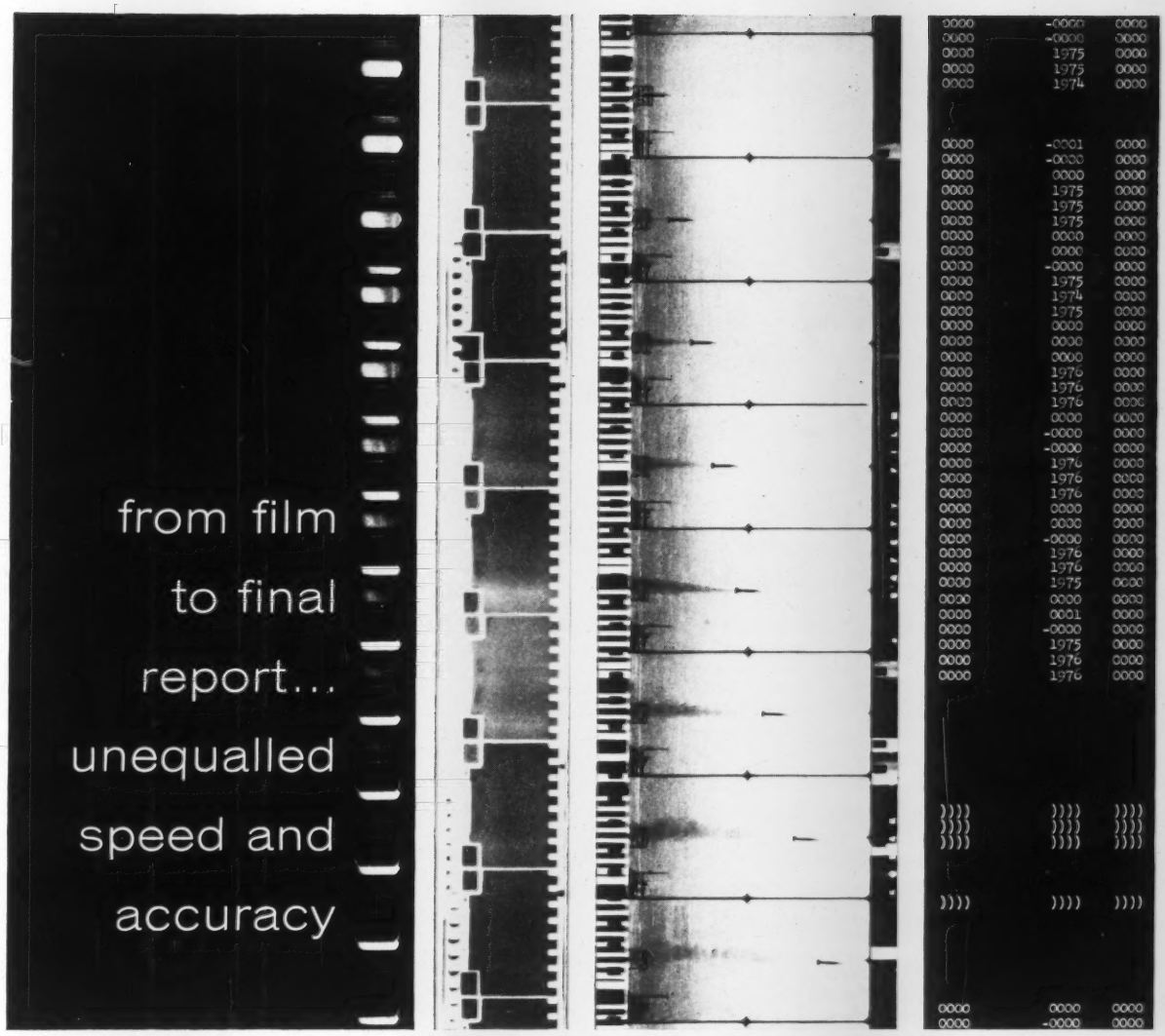
Fifth International Automation Exposition

Dates: November 16-20

Place: New York Trade Show Bldg, N. Y.

Features: Several computer clinics

*Herb's address is 1938 Sixth Street, San Diego, Calif.



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For more information circle **69** on inquiry card.

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OVER 1000 TIMES AS SENSITIVE as galvanometer recorders . . . and Varian's null-balance potentiometer needs no power from the source being measured. Rugged, stable mechanism allows ink or inkless recording—easy-to-read rectilinear chart—source impedances of up to 100,000 ohms.

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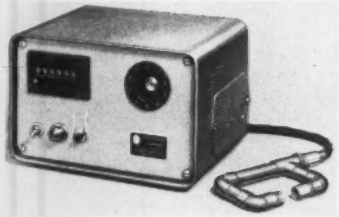
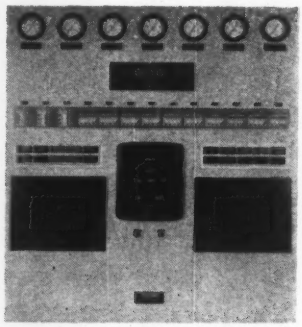


New transistorized line of electronic Count-Paks can be provided with photographs which will operate at a distance up to 30" between light-source and photocell. Counters with one glow transfer counting tube operate at 30,000 counts/min. Units are made without this decade, or with additional tubes, depending on the speed required.—*Veeder-Root Inc., Hartford, 2, Conn.*

For more information circle **141** on inquiry card.

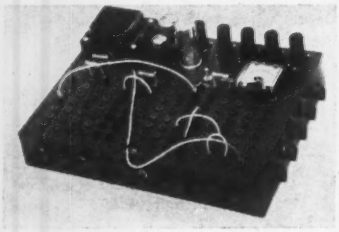
ALARM SCANNER

New Alarm Scanner provides automatic scanning of several hundred process measurements at speeds up to 5 points/sec and higher. Features of the panel-mounted system include: an auto-manual switch for manual or automatic scanning; manual switching to a precision indicator or recorder; variable scan rate; alarm setting repeatability to ±0.05 mv; and automatic reset of alarm light when audible alarm is acknowledged and measurement returns to normal.—Systems Engineering Data Bulletin, B.1.1, gives details.—*The Foxboro Company, Foxboro, Mass.*



For more information circle **142** on inquiry card.

MINIATURE ANALOG COMPUTER

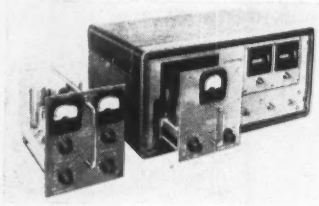


New Model MIC-2 Microlog adds, subtracts, multiplies, divides, differentiates, integrates, and does other mathematical operations. Uses plug-in cords, feedback units and input units. A separate metering unit is provided to give visual indication of the answers.—*Electronic Brain Enterprises, Inc., 1015 Atkin Ave., Salt Lake City 6, Utah*

For more information circle **143** on inquiry card.

TEXTILE INSPECTION CONTROLLER

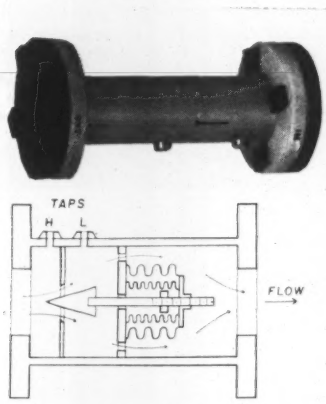
New Multicontrol Model 602 can be used with various modular plug-in broad-band amplifiers to control two Automatic Yarn Inspectors, End Break Detectors, or Thread and Line Inspectors, or a combination of any two of these devices to count defects in these operations, and can be set to automatically stop production machines when a non-permissible defect is registered.—*Lindly & Co., 248 Hericks Rd., Mineola, L. I., N. Y.*



For more information circle **144** on inquiry card.

MASS FLOWRATE METER

New primary element for measuring the mass rate of flow of gases, is basically an annular orifice in which

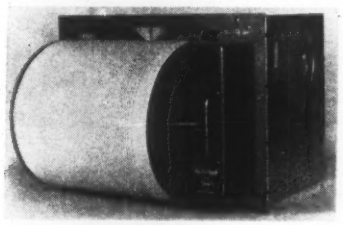


the area of the orifice is controlled by a sealed bellows unit whose length is a function of the temperature and pressure of the flowing gas. The annular space between the two concentric bellows forms a chamber in which a gas is sealed. The gas in this chamber, which is the same as the one to be measured, will be at the same temperature as the gas flowing in the line, so that the length of the bellows will be determined by the temperature and the pressure of the flowing gas. As the pressure increases, the bellows assembly shortens. The shaped plug extends farther into the orifice reducing its area. The plug shape must be matched to the characteristics of the bellows so that the annular area of the orifice is inversely proportional to the square root of the density of the gas. The square root of the differential pressure produced across the orifice is then proportional to the mass rate of flow.—*National Instrument Laboratories, Inc., 828 Evarts St., N.E., Washington, D. C.*

For more information circle **145** on inquiry card.

LONG-TERM RECORDER

New Helicorder, Model 2484, combines the features of a 1-to-3-channel analog-data recorder, an "events" or



"operations" kymograph, a quick-look monitor, and a quick data-comparison recorder; uses heated styli; has sensitivity of 15 ma (52v) per inch.—Bulletin RH-0381 contains specs and details.—*Geotechnical Corp., 3401 Shiloh Rd., Garland, Tex.*

For more information circle **146** on inquiry card.

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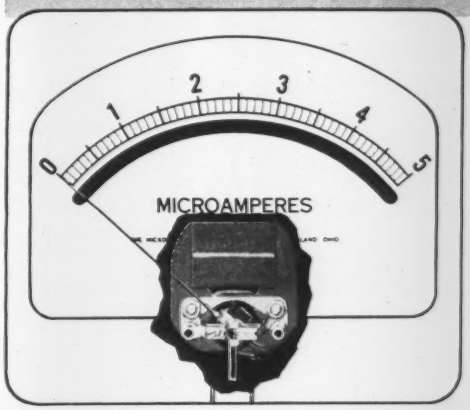

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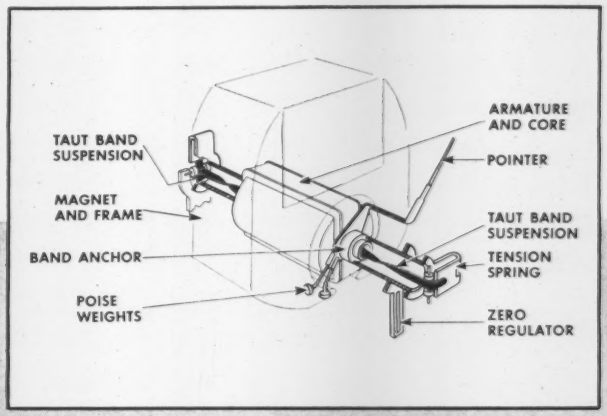

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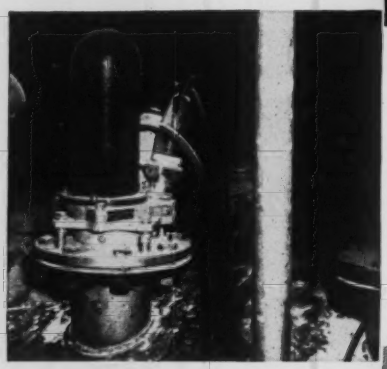

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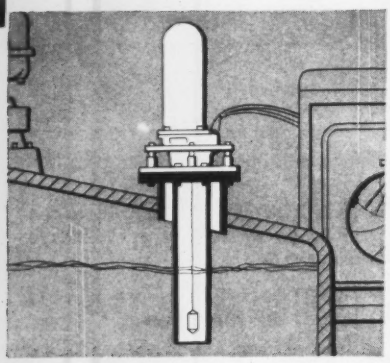

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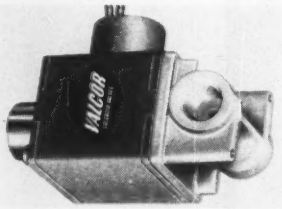
For more information circle **72** on inquiry card.

NEW INSTRUMENTS

NYLON-BODY SOLENOID VALVE

New SW-54 Series 3-way nylon-body solenoid valve with dry-seal threads is said to outlast and outperform steel. With bubble-tight sealing,



the valve is made in normally-open, normally-closed and "directional-control" configurations. Shock-resistant and pressure-proof, the SV-54 is available in all normal a-c and d-c voltages.—*Valcor Engineering Corp., 365 Carnegie Ave., Kenilworth, N. J.*

For more information circle **147** on inquiry card.

PANEL-MOUNT POT

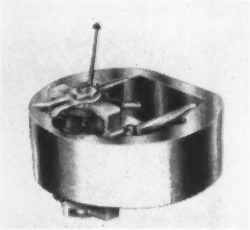
New lead-screw-actuated Model 223 Trimpot has high-temperature and humidity-proof characteristics. Available resistances ranges are from 100 to 50,000 ohms, power rating is 1 w

at 70°C; meets all applicable requirements of MIL-STD-202A including the 10-day humidity of Method 106 and vibration of Method 204.—*Bourns Labs. Inc., P.O. Box 2112, Riverside, Calif.*

For more information circle **148** on inquiry card.

BAR-RING MOVEMENT

New Bar-Ring type movement provides self-shielded instruments of maximum torque and high performance by giving maximum flux density in the working gap. A closed ring



serves as one pole of the magnetic system, with an Alnico bar magnet mounted so that one pole terminates in the ring, and the opposite polarity terminates in the pole piece. Available in all d-c panel meters and portable sizes.—*Triplett Electrical Instrument Co., Bluffton, Ohio.*

For more information circle **149** on inquiry card.

SOLENOID VALVES

New line of explosion-proof and splash-proof, Solenoid Valves, which features both normally-open and normally-closed types for automatic or

remote control of water, brine, oil, solvents, gas, air, etc., comes in nominal pipe sizes from ¼" to 3" and has temperature rating to 212° F and pressure rating to 300 psig.—*Magnatrol Valve Corp., Fifth Ave., Hawthorne, N. J.*

For more information circle **150** on inquiry card.

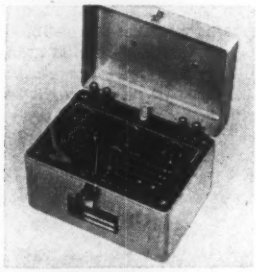
RUNNING TORQUE TESTERS

Newly developed auxiliary equipment, used in conjunction with Chatillon Running Torque testers and Dynamometers, tests the unstable section of f-h induction motors between pull-up torque and maximum torque. Useful to makers or users of shaded pole or fan motors. Torque speed curve can be traced from pull-up torque to no-load speed.—*John Chatillon & Sons. 85 Cliff St., New York 38, N. Y.*

For more information circle **151** on inquiry card.

INSTRUMENT RUN-UP UNIT

New combination millivolt and milliamp "run up" source for instrument calibrating has two voltage ranges (0 to 60 and 0 to 200 mv)



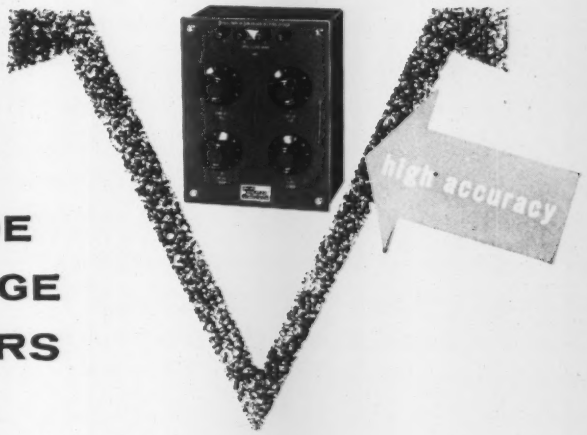
and two separate current ranges (0 to 5.0 ma or 0 to 25 ma). High-stability current adjustments are made to a resolution exceeding 0.03% by turning separate "coarse", "medium", and "fine" adjustment knobs. Power for the current source is furnished by two self-contained 90-v batteries.—*Technique Associates, Inc., P.O. Box 91, Indianapolis 6, Ind.*

For more information circle **152** on inquiry card.

DECADE BOXES

Available in 21 different types, Shallcross Decade Boxes provide resistances in 0.01 to 10,000 ohm steps up to 11,111,100 ohms. The boxes are made with precision wirewound resistors mounted on steatite-insulated switches . . . giving better than ± 0.1% accuracy above 10 ohms. Unmounted decades also available.

DECADE VOLTAGE DIVIDERS



Shallcross Decade Voltage Dividers are available in Kelvin-Varley or conventional potentiometer circuits. *Kelvin-Varley Circuit Models:* resolution to any ratio between 0.0000 and 1.0000 in steps of 0.0001 ohm; input resistances (accuracy ± 0.05%) from 10,000 to 100,000 ohms. *Potentiometer Circuit Models:* ohm steps from 0.1 to 10; total resistances from 1,000 to 100,000 ohms at ± 0.1% accuracy.

SECONDARY STANDARDS

Shallcross regularly supplies a variety of precisely-calibrated secondary resistance standards for critical research measurements. Overall stabilities better than 0.001% and maximum temperature coefficients of 3 ppm per degree C are achieved in several types.

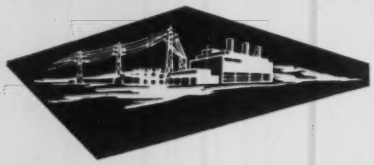
Write for more complete technical information.

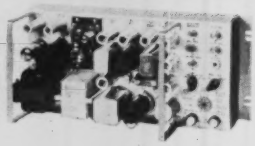
Shallcross

SHALLCROSS MANUFACTURING COMPANY, 12 Preston St., Selma, N.C.

For more information circle **73** on inquiry card.

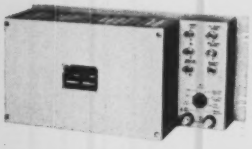
Telemeter
ANY VARIABLE
from Remote Points





MODEL 1025 Transmitter

MODEL 1090 Receiver



Accurate, Fast Acting, Frequency Type Telemeter for Transmission over Wire Lines, Microwave, and Power Line Carrier

Accurate HIGH-SPEED Continuous Telemeter for VOLTS AMPS WATTS VARS ETC.

•

Built-in Self-Calibrating Circuit

•

The Model 1025 Telemeter Transmitter converts DC mv from thermal converters, etc., to 10-30 cps which frequency modulates a built-in audio tone channel. AC 10 to 30 cps or relay outputs are also available. Receiver detects and demodulates transmitted signal, generating a DC mv for operation of recorders or indicating instruments. Up to 45 telemeters can be multiplexed.

Any communication link, including power line carrier, microwave or wire line may be used.

Over-all accuracy is 1% with a response speed of 1 second. Equipment features a built-in calibration circuit for 10% and 90% receiver check, and 10 cps and 30 cps transmitter check.

Any quantity which may be converted into a DC millivoltage or will operate a slidewire may be telemetered.

WE CAN HELP YOU

Our Applications Department is ready to assist you in your control, telemetering or communications problem. Phone DErfield 4-3100.

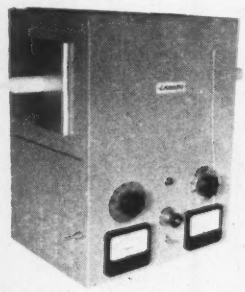
Write for Technical and Application Data.

Radio Frequency
LABORATORIES, INC.
Boonton, New Jersey, U. S. A.

For more information circle **74** on inquiry card.

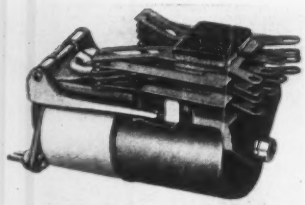
COMBUSTION TUBE FURNACES

New improved and redesigned Combustion Tube Furnaces meet the requirements of all combustion tube methods of carbon and sulphur analysis on ferrous, non-ferrous and petroleum samples. Continuous operating temperature is up to 2650° F. They are available in one-tube and two-tube models and are adaptable to 1", 1-¼" and 1-½" combustion tubes.—25-page binder contains information on pilot-plant equipment.—*Lindberg Engineering Co., Laboratory Equipment Div., 2444 West Hubbard St., Chicago 12, Ill.*



For more information circle **153** on inquiry card.

LONG-TIME D-C DELAY RELAY

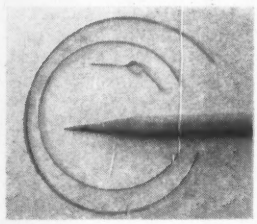


New heavy-duty telephone-type Relay features increased time delay with great coil power. Operate-delay is up to 0.15 sec and release-delay up to 0.25 sec. Available with a great variety of contact combinations, and contacts from bifurcated gold alloy (for dry circuits), to 10-amp heavy-duty contacts for power switching. Furnished for d-c operation only.—*Magnecraft Electric Co., 3350L W. Grand Ave., Chicago 51, Ill.*

For more information circle **154** on inquiry card.

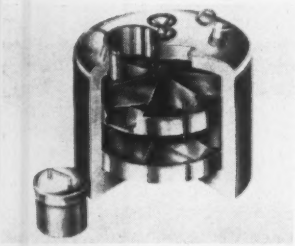
SUBMINIATURE THERMOCOUPLE

New subminiature Thermocouples, which are fully metal-clad and ceramic-insulated from the high-temperature sheath, are readily formed. They range from 0.020" OD, 2-wire; to 0.040" OD, 2-wire. Available from stock in several sheath materials and most conductor combinations.—*Pyro-Electric, Inc., Dept. DE, P.O. Box 232, Barrington, Ill.*



For more information circle **155** on inquiry card.

NON-MECHANICAL REFRIGERATOR

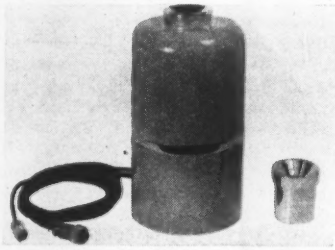


New large capacity Liquid Nitrogen Refrigerator LNR-640 B, is designed to store 17-½ cu ft of product at temperatures to −320°F, the boiling point of liquid nitrogen. Biologicals, chemicals, metallurgical samples, etc. can be stored in two 40" trays.—*Linde Company, Div. of Union Carbide Corp., 30 E. 42nd. St., New York 17, N. Y.*

For more information circle **156** on inquiry card.

SCINTILLATION WELL COUNTER

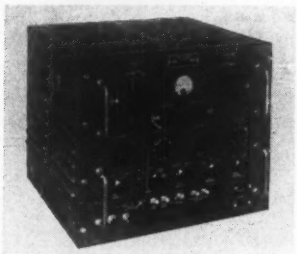
New Scintillation Well Counter, Model SWC-1, has 2" of lead shielding in a sectionalized unit of 7" dia by 12¼" high, weighing only 95 lb. The scintillation probe comes equipped with a 2" x 2" NaI crystal, has a well for 1" dia samples and includes a built-in preamplifier.—*Nuclear-Electronics Corp., 2925 N. Broad St., Phila. 32, Pa.*



For more information circle **157** on inquiry card.

HI-LEVEL SIGNAL GENERATOR

New Model 80 High Level Signal Generator features excellent stability and constant high-level output of pulse-modulated r-f signals in the 10-

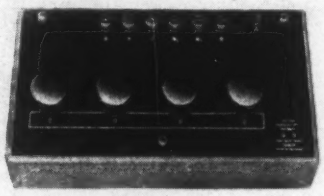


cm band over a frequency range of 2700 to 3000 megacycles. Output is internally monitored, continuously adjustable to as much as 10 w peak, and indicated by a meter mounted on the front panel. Controls are direct reading, eliminating the need for calibration charts.—*BJ Electronics, Borg-Warner Corp., 3300 Newport Blvd., Santa Ana, Calif.*

For more information circle **158** on inquiry card.

RATIO SET

New Otto Wolff 4-dial direct-reading Ratio Set, with a precision of 1 ppm, affords an easy, quick and pre-

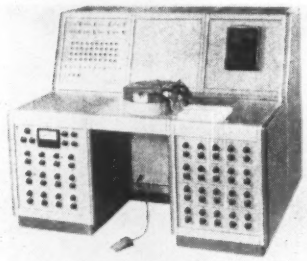


cise method of comparing high-precision resistors against known standards.—*Physics Research Laboratories, Inc., P. O. Box 555, Hempstead, N. Y.*

For more information circle **159** on inquiry card.

TRANSISTOR TESTER

New Transistor Tester, a high-speed production machine, automatic grades and sorts 1200 units per hour. It makes 8 different tests of any one

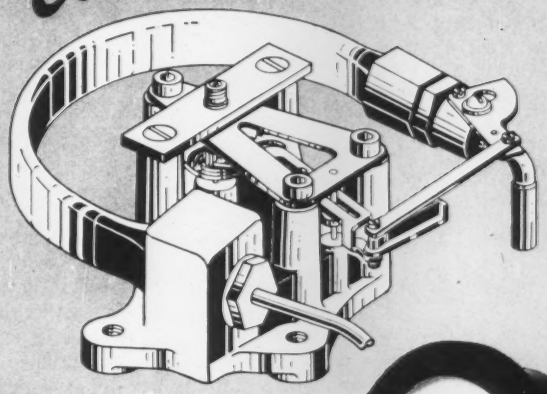


transistor type and is fail-safe in operation. It has a patchboard programming system, permitting the selection of any type d-c test and sequence.—*Eder Engineering Co., 1568 South First St., Milwaukee 4, Wis.*

For more information circle **160** on inquiry card.

HEISE GAUGES

NEW Automatic Thermal Compensator



Heat and cold have no effect on the Heise High Precision Pressure Gauge equipped with the new Thermal Compensator. (Patent applied for)

Developed by the Heise Laboratories, manufacturers of the world's finest pressure measuring instruments, this unique device now eliminates all error due to thermal variations. Pointer errors caused by linkage growth and changing modulus in the Bourdon Tube are positively and precisely compensated by the equal and opposite action of a scientifically designed and balanced bimetal bar to maintain calibration through a temperature range from 0° to 100°F.

Even exposed to rapidly changing weather outside the confines of the laboratory, the Heise Gauge upholds its traditional position as

THE STANDARD OF THE WORLD

Pressure Ranges 15 to 20,000 P.S.I. Dial Sizes 8½"-12"-16"

Prices from $196.75 **DELIVERY WITHIN 30 DAYS**

Write for Catalog

HEISE BOURDON TUBE COMPANY, INC.

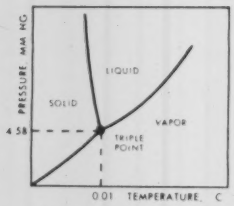
BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

For more information circle **75** on inquiry card.

Scientific Announcement

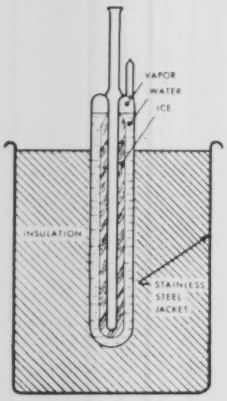
NEW PRIMARY STANDARD FOR TEMPERATURE

A new primary temperature standard, using the triple point of water, is now in use in national standards laboratories throughout the world. This new standard defines the triple point of water as 0.01°C. It has been recommended by the International Committee on Weights and Measures as the standard for the International Temperature Scale, and is already the standard on the thermodynamic scale (273.16K).



Phase Diagram for H_2O

The triple point of water is attained by partially freezing pure water in an evacuated and sealed glass system. A triple point of water cell maintains its true reference temperature of 0.01°C when ice, water and water vapor exist at 4.58 mm Hg.



Equiphase Cell

Triple Point Cells which meet the exacting requirements for use as a primary temperature standard are now available from Trans-Sonics,Inc. in a convenient, easy-to-use package. Called an Equiphase* Cell, this instrument is ideal for use in research laboratories, quality control and standards departments, or wherever a highly accurate and reliable primary temperature standard is required. Equiphase Cells come complete with full instructions for use, and are constructed so there is no possibility of contamination with consequent loss of accuracy. Write for Equiphase Cell Technical Bulletin to Trans-Sonics, Inc., Dept. 19, Burlington, Mass.

*T. M.

TRANS-SONICS T.M.

Precision Transducers

For more information circle **76** on inquiry card.

NEW INSTRUMENTS

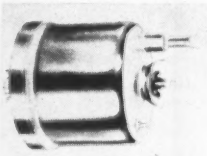
DYNAMIC DEMONSTRATOR

New Electronic Teaching Device is an operating television receiver on breadboard, designed to teach the basic principles of electronics from the fundamental electronic circuits through radio and television, by using a new type of connecting device which requires no soldered joints.—*Transvision, Inc.*, 460 *North Ave., New Rochelle, N. Y.*

For more information circle **161** on inquiry card.

VIBRATING CAPACITOR

New Vibrating Capacitor, which features an assembly hermetically sealed and filled with inert gas to minimize drift in constant potential,

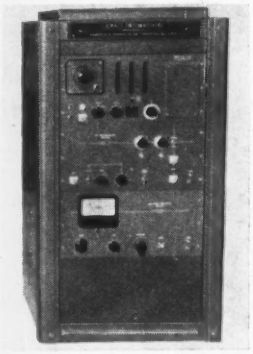


is designed for converting from d-c to proportional a-c voltage for amplification. Conversion efficiency is greater than 12% ratio of a-c rms voltage output to d-c voltage applied at specified excitation.—*Tracerlab, Inc.*, 1601 *Trapelo Rd., Waltham* 54, *Mass.*

For more information circle **162** on inquiry card.

MANUAL SPECTROMETER

New N-126PM Manual Spectrometer for qualitative and quantitative analysis of the energy spectra of gamma emitting isotopes is completely enclosed in a 2" sectional lead shield that reduces the background

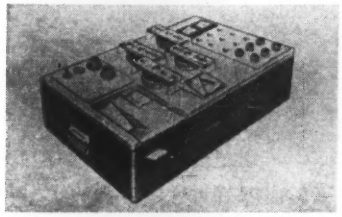


count to as little as 25 cpm with the window fully open. System consists of N-302 Amplifier; N-372 Scintillation Counter; N-401 Power Supply; N-230-T Decade Scaler and Timer. Energy range is 25 KeV to 8 MeV; Linearity is 0.15%.—Condensed pocket-size catalog contains all Nuclear Instruments manufactured by company.—*Hamner Electronics Co., Inc., P. O. Box* 531, *Princeton, N. J.*

For more information circle **163** on inquiry card.

POTENTIOMETER CHECKER

New PC-15 checker consists of a 10-turn potentiometer which permits mounting and phasing of potentiometer under test and coupling its shaft to the mechanism which drives the

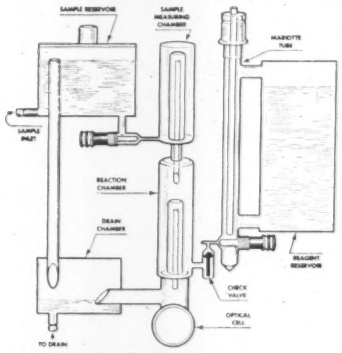


master and test potentiometer and the recorder paper drive; a recorder; trimming facilities for zeroing and error; and a calibration source. Output voltage is a linear function of test pot shaft rotation. Accuracy of master is 0.002%, resistance 100K ±5%, power required is 115 v, 60 cps, 3 amps.—*Analogue Controls, Inc., 39 Roselle St., Mineola, N. Y.*

For more information circle **164** on inquiry card.

COLORIMETRIC ANALYZER

New Chemalizer, developed in Belgium, automatically makes colorimet-



ric analyses in a fraction of the time formerly needed.—*Florida Instrument Co., 1300 East Mermaid Lane, Phila. 18, Pa.*

For more information circle **165** on inquiry card.

WIRING KIT

New kit contains an extensive sampling of solderless electrical terminals and matching application tool-

ing and is available only for use in research and development.—*AMP Incorporated, Harrisburg, Penna.*

For more information circle **166** on inquiry card.

TRANS-SONICS

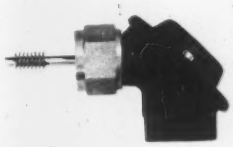
T.M.

PLATINUM TEMPERATURE TRANSDUCERS

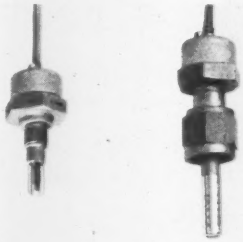
for measurement, telemetry, and control

- TEMPERATURES FROM −425 TO +1832 F.
- PRECISION CALIBRATION
- ACCURACIES TO 0.1 F.
- 5 VOLT OUTPUT
- HIGH RESPONSE SPEED

1300 Series



Type 2135



1350 Series

Type 1321

BULB TYPE for corrosive gases and liquids

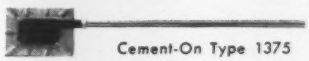
1300 Series transducers are available in ranges from −400 F to +1832F, feature 1% accuracy, stainless-steel construction, and a time constant of less than 2.5 seconds in agitated liquid. Many standard and special bulb lengths are available.

Type 2135 has ±0.25 F accuracy and interchangeability over a range of 0 to +125 F. The platinum element is enclosed in a nickel-plated bulb, and the unit will withstand a working pressure of 4500 psi.

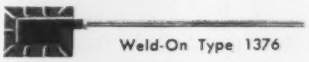
OPEN TYPE for non-corrosive gases and liquids

1350 Series transducers are available in ranges from −300 F to +600 F, with an accuracy of ±1% full scale. The platinum sensing element comes in direct contact with the gas or liquid being measured, resulting in a typical response time of 0.2 second in agitated liquid.

Type 1321 is designed for extreme low temperature measurements, with special calibrations to −425 F. Operating interval is 30 F in ranges up to +250 F, with ±1% accuracy. A perforated shield protects the platinum sensing element from high flow rates.



Cement-On Type 1375



Weld-On Type 1376

SURFACE TYPE for all kinds of surfaces

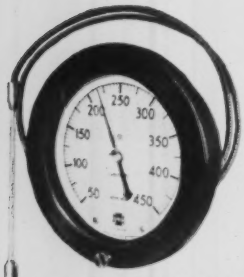
These platinum temperature transducers can be installed by a variety of methods on any surface . . . flat or curved, metallic or non-metallic. The following types are available in ranges from −400 F to +1850 F: Cement-On, Weld-On, Tape-On, Thermopaper, Sub-Surface, and Surface Transferable.

A five-point resistance-temperature calibration certificate at 0, ¼, ½, ¾, and full scale temperature is supplied with each transducer. Custom designs for all temperature transducers are available on special order with accuracies to 0.1 F. Write to Trans-Sonics, Inc., Dept. 19, Burlington, Mass. for Condensed Catalog on Platinum Temperature Transducers.

TRANS-SONICS

Precision Transducers

For more information circle **77** on inquiry card.



NEW
FROM U. S. GAUGE

SUPERTHERM dial thermometers

Engineered . . . to equal the premium quality and dependable performance of superior USG Grade AA Supergauge pressure gauges.

Priced . . . at a money-saving value that's news in itself.

Designed . . . in a range of styles and sizes to serve any plant in any industry with the *most comprehensive line of indicating thermometers available from one source today!*

NOW all your requirements for standard, filled system dial thermometers met with one top grade line that features all these specifications. See your USG distributor, or write for Catalog 205.

DIRECT READING—rigid, direct mounting; or "Multi-Angle" type

REMOTE READING—for temperature measurement up to 125 feet from indicator

4 TYPES OF FILLS—organic liquid, gas, vapor, mercury

ALL COMPENSATIONS—complete selection of case or capillary compensation available as required

29 STANDARD RANGES—covering temperatures from −350° to +1000°F

2 CASE MATERIALS—anodized aluminum or phenolic plastic

4 CASE SIZES—3½", 4½", 6" and 8½"

3 CASE STYLES—turret, front flange, or back flange mounting, with choice of bezel

FULL SELECTION OF BULBS—virtually endless combinations of bulb sizes, shapes, materials, and connections.

Find Your Nearest Distributor in The 'Yellow Pages'

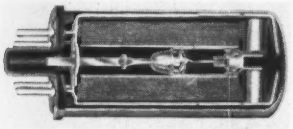
UNITED STATES GAUGE USG
Division of American Machine and Metals, Inc. • Sellersville, Pa.

For more information circle **78** on inquiry card.

NEW INSTRUMENTS

CONTACT RELAY

New Clare Type HGS mercury wetted contact relay is always biased with permanent magnets which are adjustable for single-side stable or

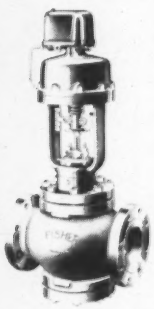


bi-stable operation. Operating speeds to 200 cps, sensitivity ±2.5 mw for bi-stable adjustment, 5 mw for single-side stable adjustment. Contact rating is 2 amps, 500 v with a limit of 100 volt-amps.—*C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Ill.*

For more information circle **167** on inquiry card.

PISTON OPERATOR

New high-pressure Pneumatic Piston Operator, Type 470 "P.O.P." is for applications where more force and higher stroking speeds are required than are available from dia-

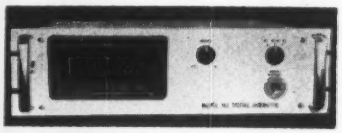


phragm operators. It includes an enclosed positioner mounted on the cylinder, suitable for a wide range of instrument signals. It operates on any supply pressure up to 150 psi and creates stem forces from 1500 to 12,000 lb. Stroking speeds range up to 1.5"/sec.—Bulletin E-59 contains details.—*Fisher Governor Co., Marshalltown, Iowa.*

For more information circle **168** on inquiry card.

DIGITAL OHMMETER

New Model 781 Digital Ohmmeter features an illuminated readout and sound-insulated stepping switches.

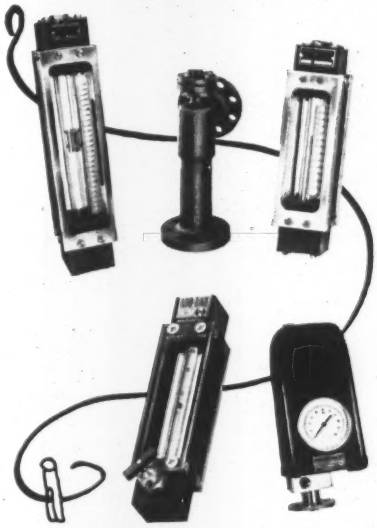


Five ranges are available from 0.1 to 10 megohms with an accuracy of 0.05% of reading +1 digit.—*Non Linear Systems, Inc., Del Mar, Calif.*

For more information circle **169** on inquiry card.

BROOKS LEADERSHIP
achieved through design

ROTAMETERS



a FULL LINE
for every service

Whatever your flow measurement or remote transmission needs . . . Brooks has the answer. Moreover, it is a *practical* answer . . . because the same practical design features are carried through the line. From Hi-Accuracy Flow Indicators to low-cost purge meters . . . from the well-known Ar-Met Armoured Meter to the new convertible electric or pneumatic flow transmitters, you'll find these common features: self-alignment of essential parts, simplified cleaning and assembly, and designs that eliminate troublesome line strain on the metering elements.

You can depend on Brooks rotameter equipment for *lowest final cost* all down the line—because it has been performance-proven where it counts most: in daily service.

Send for your copy of Bulletin 110b, a brief, well illustrated guide to Brooks Rotameters and Accessory Equipment.

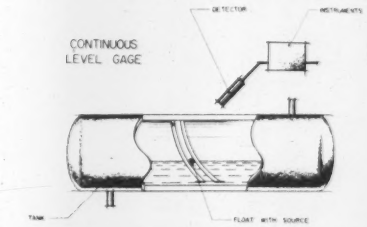
BROOKS ROTAMETER COMPANY
259 J Street, Lansdale, Pa.

the new standard of flow measurement and control

For more information circle **79** on inquiry card.

CONTINUOUS LEVEL GAGE

New Model 40104 measures level of liquids in totally-enclosed containers by means of small radioactive source, mounted in a float, which follows the level of liquid along a path predeter-



mined by guide lines placed inside the tank. Radiation emitted by the source is detected by a scintillation detector located outside the tank. Changes in the level of the liquid cause changes in the strength of radioactivity detected. This change is then calibrated in linear distance or volume.—*Radiation Counter Laboratories, Inc., 5121 W. Grove, Skokie, Ill.*

For more information circle **170** on inquiry card.

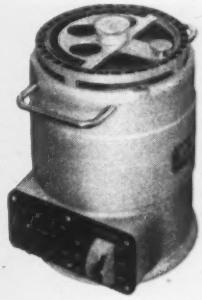
JEWELED ESCAPEMENT

New 31-day Chart Drives have movement with seven jewels: four at the chart drive's balance wheel pivots, one on the balance wheel roller pin, and two on the verges of the pallet fork. Turrets give eight-day, 15-day, 16-day, 24-day, 30-day, 31-day and 24-hour rotation.—*Rockwell Mfg. Co., Meter and Valve Div., 400 North Lexington Ave., Pittsburgh 8, Pa.*

For more information circle **171** on inquiry card.

PHASE SHIFTER

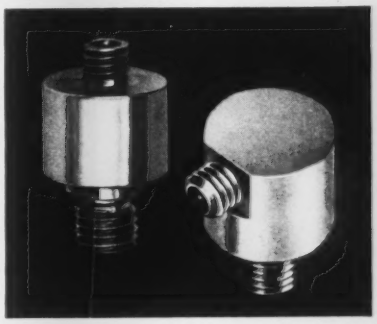
New 400-cps Phase Shifter provides any phase shift from 90°-leading to 90°-lagging in the testing of electronic equipment and their control circuits, watthour meters, rotating standards,



wattmeters, powerfactor indicators, etc. Two direct-reading scales (the outer scale calibrated in degrees for the electrical angle of displacement, the inner scale calibrated in corresponding power-factor values) permit true-power-factor reading directly.—*Knopp Inc., 1307 66th St., Oakland 8, Calif.*

For more information circle **172** on inquiry card.

Avoid false test results with GLENNITE internally ungrounded accelerometers



Now you can avoid one of the major causes of false test results – spurious "ground loop" voltages – by using *internally ungrounded* GLENNITE accelerometers.

These units contain sensitive seismic elements *internally* insulated from the mounting stud by rugged ceramic insulation. You can employ a *single point ground* at the data handling or recording equipment by using a combination of these accelerometers with ungrounded GLENNITE amplifiers and filters.

GLENNITE accelerometers are available in uni- and triaxial models – wide acceleration and temperature ranges.

A complete line of associated ungrounded electronic equipment includes filters, amplifiers, connectors and other related units.

For complete data on Gulton instrumentation systems – grounded or ungrounded – contact your local Gulton representative or write us direct.

Call in Gulton

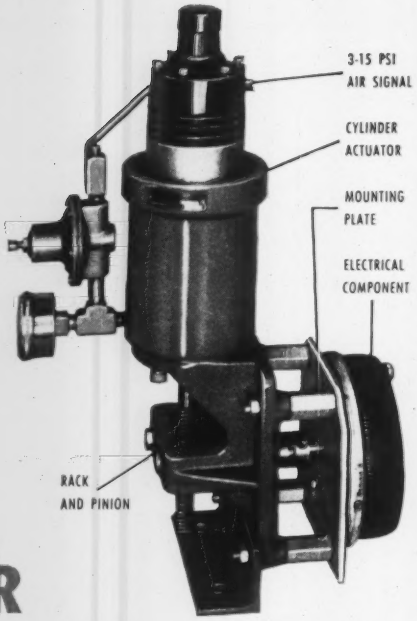
From transducer to readout, Gulton is capable of meeting all your instrumentation needs. If you have a measurement problem, why not call in a Gulton Instrumentation Engineer. His broad experience in shock and vibration measurement can prove invaluable to you.

GULTON INSTRUMENTATION DIVISION

Gulton Industries, Inc.
Metuchen, New Jersey

For more information circle **80** on inquiry card.

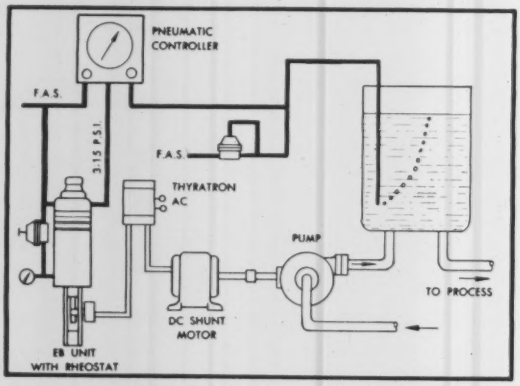
ELECTRIC CONTROL FROM A PNEUMATIC SIGNAL WITH THE CONOFLOW MODEL EB CURRENT CONTROLLER



The Model EB Current Controller—an exclusive product of Conoflow Corporation—is a unique final control element. It is a pneumatic-electric transducer consisting of a pneumatic cylinder actuator fitted with a rack and pinion mechanism, and a standard electrical component such as a rheostat, potentiometer or autotransformer. The cylinder actuator, operating from a 3-15 psi air signal, produces a rotary motion (to 360°) to precisely position the electrical device affording automatic control of voltage, current, inductance, capacitance, resistance, or other electrical values.

APPLICATIONS—Conoflow Model EB Current Controllers are available from the factory in over 200 combinations of electrical components to handle a wide variety of applications. A few of these include:

- **Constant Pressure**
- **Proportional Flow**
- **Liquid Level**
- **Temperature Control**
- **Machine Tool Speed**
- **Conveyor Control**
- **Heat Treating**
- **Humidity Control**



A TYPICAL EXAMPLE

Direct flow regulation by varying pump speed is accomplished when the EB unit is used with a pneumatic controller and an electronic speed changer. It automatically positions the small rheostat in the grid circuit of a thyratron controlled speed changer, thereby adjusting motor and pump speed. This method of flow rate control can be used to provide control of temperature, pressure, pH, interface, or liquid level. It eliminates the valve, reduces motor power input, and provides for positive flow rangeability.

The EB unit with cylinder directly coupled to the armature or field rheostat of a DC shunt wound motor is also widely used for motor speed control.

For additional information on the Model EB Current Controller write to Conoflow Corporation, 2100 Arch Street, Philadelphia 3, Pa., for Bulletin EB-3A.

CC-804

Conoflow Controls®

CONOFLOW CORPORATION

FOREMOST IN FINAL CONTROL ELEMENTS

Subsidiary of Walworth

For more information circle **81** on inquiry card.

LIQUID LEVEL CONTROLS

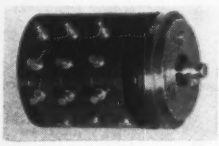
New single-stage narrow-differential liquid level controls, Models A-152-F and A-153-F, handle liquids of

specific gravity 0.30 and up, at temperatures to 500°F and pressures to 5000 psig. Displacers are available in Karbate, porcelain, stainless steels, etc. Interface applications are also possible.—*Magnetrol, Inc., 2110 S. Marshall Blvd., Chicago 23, Ill.*

For more information circle **173** on inquiry card.

GANG-TYPE POT

New Model 319 Gang Type Potentiometer makes possible non-linear and sine-cosine functions. It is available in resistance values up to 200K

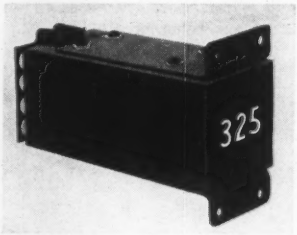


with 0.05 linearity. Power output is 2 w. Meets all applicable Mil-E-5272A and Mil-STD-200 requirements and complies with many Mil-R-19 and NAS-710 requirements.—*Daystrom Pacific, Potentiometer Div., 9320 Lincoln Blvd., Los Angeles 45, Calif.*

For more information circle **174** on inquiry card.

IN-LINE DISPLAY UNIT

New special-purpose 16-Position In-Line Display unit displays three numbers (0 through 9) simultaneously a + or − symbol, or any combination



thereof. It features one-plane presentation, in that all characters and/or numbers appear on the front surface of the display unit.—*Industrial Electronic Engineers, 3973 Lankershim Blvd., North Hollywood, Calif.*

For more information circle **175** on inquiry card.

If the cost of metal stampings and wire forms figures in your profit picture, let us give you a quotation on your current components. Send us a sample or blueprint . . . and discover how big savings in time and production costs, big gains in precision and uniformity are possible on small components, when Art Wire tackles the job!

Our engineering staff, our production experience, and our modern high speed equipment are always at your disposal. If you wish to learn more about what a wide and versatile range of shapes and parts we can produce for you—at lower cost than you'd guess—just write for our illustrated folder.

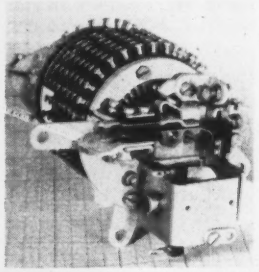
ART WIRE AND STAMPING CO.

35 Boyden Place, Newark, New Jersey

For more information circle **82** on inquiry card.

MINIATURE STEPPING SWITCH

New high-speed Miniature Uniselector for automatic switching and timing-control circuits operates at speeds

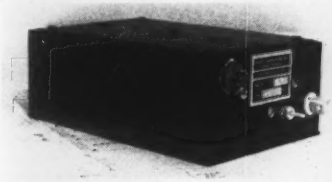


up to 80 steps per sec on impulse drive (80% make, 20% break) from a power supply of 24, 50 or 110 vdc. Up to twelve banks can be fitted.—*Imtra Corp., 11 University Rd., Cambridge 38, Mass.*

For more information circle **176** on inquiry card.

TRUE-FM TRANSMITTER

New Model TR-12 Telemetering Transmitter features true-FM operation and is crystal stabilized. Unique circuitry affords highly stable per-

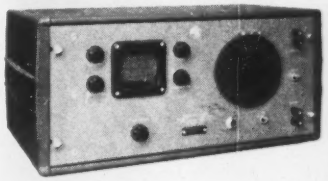


formance, with a wide frequency tuning range from 225 to 260 mc. True-FM design permits a full 125-kc deviation over a modulation range of from 300 cps to 80 kc with only 1% distortion.—*Dorsett Laboratories, Inc., 401 East Boyd St., Norman, Okla.*

For more information circle **177** on inquiry card.

PRIMARY PHASE STANDARD

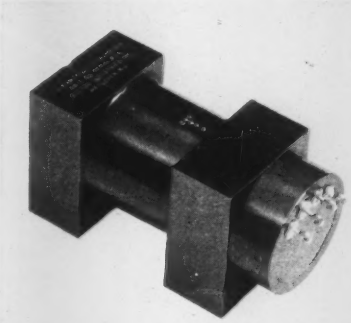
New Type 706-A Ultrasonic Primary Phase Standard generates two sinusoidal voltage signals whose phase difference can be varied smoothly from 0° to 360° with an ac-



curacy of 0.1°. Units are built for any single frequency from 20 kc to 200 kc. The instrument can be used for calibrating high-frequency phase meters and phase detectors, and phase shifting devices in general. Operation is based on the interpretation of a multiple-frequency Lissajous pattern.—*Acton Labs. Inc., 533 Main St., Acton, Mass.*

For more information circle **178** on inquiry card.

Magnetic damping in minimum volume



with GLENNITE® AW-1 linear potentiometer accelerometers

For the first time, *magnetic damping in a small, light weight, efficient package!*

Utilizing a new seismic suspension which considerably reduces friction and hysteresis, the GLENNITE AW-1 Series accelerometers have minimum lateral sensitivity and excellent linearity. These instruments meet requirements of MIL-E-5272A, as amended, and may be mounted either parallel to or perpendicular to the sensitive axis.

Available in ranges ±1 to ±10g full scale. And with tap settings as required.

Call in Gulton

Whether you need a single instrument or a complete system, Gulton is capable of meeting all your needs in acceleration measurement and control from transducer to readout equipment. Call in a Gulton Instrumentation Engineer on your next assignment—or on your present one if you have a problem.

GULTON INSTRUMENTATION DIVISION

Gulton Industries, Inc.

Metuchen, New Jersey

For more information circle **83** on inquiry card.

RELIABILITY... THE SOLUTION TO YOUR ELECTRONIC COMPONENT PROBLEMS

Designing reliability into electronic components and instrumentation is Borg Equipment Division's business. Borg's reliable engineering, research and production facilities are at your service for commercial or military projects. Bring your component reliability problems to Borg. You'll enjoy working with our cooperative, creative engineering staff. The result will be a sound, practical and reliable solution at a considerable saving of time and money. Here are just a few of the products manufactured by Borg . . .

- FREQUENCY STANDARDS
- AIRCRAFT INSTRUMENTS
- POTENTIOMETERS
- MULTI-TURN COUNTING DIALS
- FRACTIONAL H. P. MOTORS
- SPECIAL DESIGNS

WRITE FOR COMPLETE ENGINEERING DATA

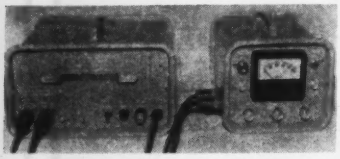
BORG Built by Borg

BORG EQUIPMENT DIVISION
AMPHENOL-BORG ELECTRONICS CORPORATION
JANESVILLE, WISCONSIN

For more information circle **84** on inquiry card.

ELECTRIC SYNCHROLIGHT

New Model WE-1-D Synchrolight is a high-intensity stroboscopic light for observing and analyzing high-speed mechanical motion or vibration. New patented bulb permits it to be

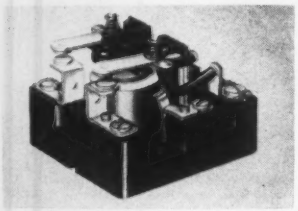


used in work areas of normal ambient light. The flashing rate can be manually varied from 10 cps to 400 cps (600 to 24,000 rpm) in 3 ranges. The frequency is read on a 4-in meter which can also be used as a VTVM (10 mv to 100v) for amplitude measurements when the light is used in vibration analysis.—*Westport Electric, 149 Lomita St., El Segundo, Calif.*

For more information circle **179** on inquiry card.

POWER RELAY

New 2210-U 25-amp heavy-duty power relay meets UL specs. Contact arrangement is DPST, normally open.

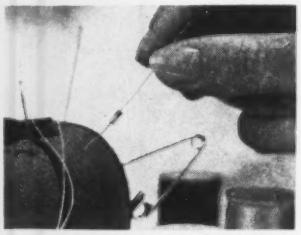


Has interchangeable coil assembly.—*Guardian Electric Mfg. Co., 1621 W. Walnut St., Chicago 12, Ill.*

For more information circle **180** on inquiry card.

MINI TANTALUM CAPACITOR

New Type HAT sintered-anode electrolytic capacitor for miniature transistorized devices is less than ⅜" in dia, and about ⅛" long. D-c leakage



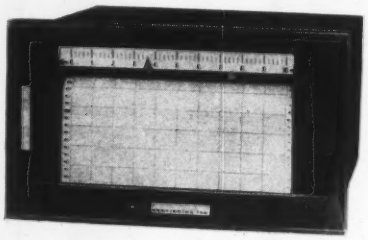
current is less than one micro-amp. Leads are welded for extra length and units sealed with color coded epoxy for protection and identification. Suitable for by-pass coupling and filter applications. Available in ratings of 1 to 10 microfarads and ratings of 1 to 10 v.—*P. R. Mallory & Co. Inc., 3029 E. Washington St., Indianapolis 6, Ind.*

For more information circle **181** on inquiry card.

Where there's no margin for error...

westronics

RECORDING POTENTIOMETERS



11" CHART AVAILABLE WITH ONE or TWO PENS RECORDING FULL SCALE

FEATURING

SMALL SIZE

- Only 60% the size of old line instruments
- Designed for standard relay rack mounting

VERSATILITY

- Minimum span—1 MV
- Plug in range, MV or TC
- Chart drives, synchronous and/or selsyn, with large selection of speeds
- Marker pens, L and/or R
- Limit switches
- Transmitting slidewires

Also available: One and two pen 5" recorders

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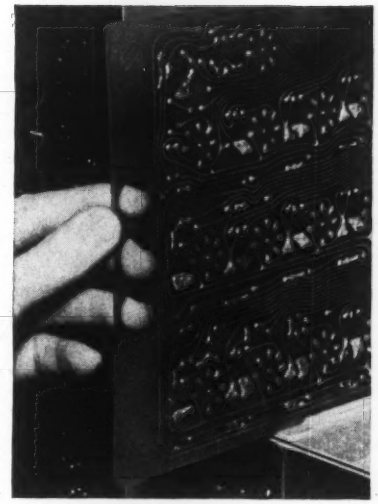
3605 McCART STREET • FORT WORTH, TEXAS

For more information circle **85** on inquiry card.



Now . . . "telephone quality"

PRINTED CIRCUIT BOARDS

from Stromberg-Carlson

Expanded facilities now make it possible for you to get the *same* high quality printed circuit boards we produce for our own telecommunication and electronic applications.

We print and etch one or two sides; we provide eyelets or terminals and can provide gold plating where desired.

All boards will be manufactured with the same rigid process control demanded by our electronic switchboard, automatic toll ticketing, carrier and other precision equipment. In addition, you get these chief advantages:

1. **Quality:** assured by rigid control over incoming materials as well as process.
2. **Low Cost:** low tooling cost on quality short-run precision work means lower cost to you.
3. **Volume:** screen printing makes volume production economical. Delivery to meet your scheduling.
4. **Excellent Solderability** is assured without the need for costly solder plating.

Tell us about your particular job requirements. We will furnish price and delivery information immediately.

STROMBERG-CARLSON

A DIVISION OF GENERAL DYNAMICS CORPORATION

Telecommunication Industrial Sales
113 Carlson Road, Rochester 3, N. Y.

S-C

For more information circle **86** on inquiry card.

TRANSISTOR TIMER

New Transistorized Time Delay Relay for intervals from 50 msec to 4.0 min for operation from external power supply of 40 v to 60 vdc at 0.050 Ma max, features accuracy ±4% over

a supply voltage variation of ±10 vdc. Repeatable accuracy is better than 1% for any time cycle. For single-pole double-throw control circuits up to 3 amps @ 28 vdc or 115 vac sustained operation.—*Automatic Timing & Controls, Inc., Dept. 204, King of Prussia, Penna.*

For more information circle **182** on inquiry card.

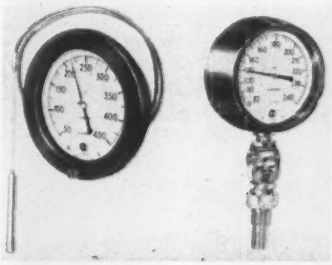
PROTECTIVE COATING

New Tycote, an acid and alkali resistant coating for use on new or already-in-use tubes and fittings, protects them from any harmful effects just from being exposed to such fumes. Tycote can either be painted on fittings or tubes with a brush, or the parts can be dipped in the liquid. Available in either black or clear in containers from ½ pint to a gallon.—*C. B. Crawford Co., 16606 Waterloo Rd., Cleveland 10, Ohio.*

For more information circle **183** on inquiry card.

DIAL THERMOMETERS

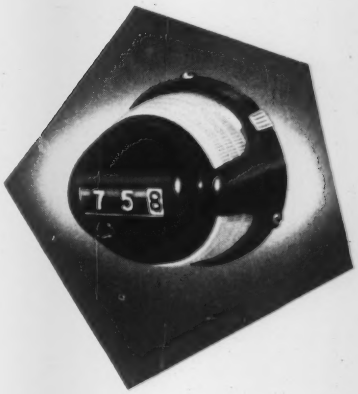
New completely-redesigned line of Supertherm Indicating Dial Thermometers for measuring temperatures in the range of −350° F to +1000° F includes remote- and direct-reading types, the latter with rigid stem or for angle reading. Filling me-



dia are vapor, gas, mercury, and organic liquid. Each covers a definite temperature range and each has certain advantages for specific applications. Dial sizes offered are 3½, 4½, 6, and 8½" except for mercury or organic-liquid-filled and the multi-angle models which are not offered in the 3½-inch size.—*United States Gauge Div. of American Machine and Metals, Inc., Sellersville, Penna.*

For more information circle **184** on inquiry card.

NOW FROM BORG... A NEW LIGHTWEIGHT MICRODIAL!



You asked for it . . . here it is! The all-new, lightweight Borg Microdial. An anodized aluminum control knob makes this dial light, bright and more attractive. Three rows of knurled bands make setting quick, easy. Wear and corrosion resistant . . . meets fifty-hour salt spray requirements. Presently available in 3-digit, 10-turn models with or without finger-tip brake which locks settings in place. The aluminum control knob is mounted directly on the shaft to be controlled — this prevents backlash. Inline digital presentation makes the easiest dial reading ever. See your Borg "Tech-Rep" or write direct for more information.

MICROPOTS • MICRODIALS • MOTORS

BORG

Built by Borg

BORG EQUIPMENT DIVISION

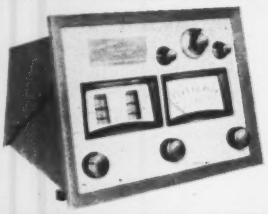
AMPHENOL—BORG ELECTRONICS CORPORATION
JANESVILLE, WISCONSIN

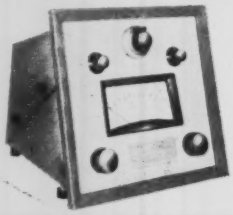
For more information circle **87** on inquiry card.

Therma Bridge

THERMAL CONDUCTIVITY EQUIPMENT

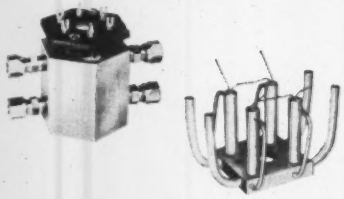
NEW... design concepts





COMPLETE line of instruments and cells

for thermal conductivity measurements



Now . . . a complete line of precision instruments housed in advanced, functionally designed cabinets with latest refinements in circuitry and design.

Advanced design "Therma Bridge" sensing cells, the heart of all gas conductivity measurements are available in two metal mass weights. A heavy-weight, open core, hexagonal cell and light-walled, individual cavity cell. Both cells are available with either hot-wire or thermistor sensing elements.

Instruments include Therma Bridge Gas Analyzer for monitoring purity values in gas streams and for wide applications in gas impurity analysis; Therma Bridge Stabilized Temperature Sensing Unit for use in low impurity percentages in gas analysis and chromatography, as well as for measurements at elevated temperatures; Therma Bridge Power Supply and Control Circuit Unit the power source for all thermal conductivity sensing cells.

All equipment is designed for rack or individual mounting. Special custom design service for special applications. Write today for complete technical details on the full line of Therma Bridge Gas Thermal Conductivity Instruments and Cells to . . .

Industrial Instruments Engineering Corp.

Industrial Instruments Engineering Corp.

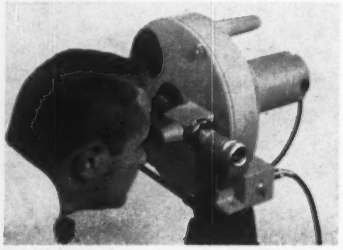
89 Commerce Road, Cedar Grove, Essex County, N. J.

For more information circle **88** on inquiry card.

NEW INSTRUMENTS

HIGH-SPEED CAMERA

New Dynafax Camera provides high-speed motion-analysis photographs at an upper rate of 25,000 16-mm frames/sec. Other features include a stable framing rate during the operating cycle which is continu-



ally indicated on a built-in meter; absence of synchronizing requirements; exposure times easily adjustable between 1 and 5 usec at the maximum rated framing speed of the camera; total writing time of 9 usec at 25,000 frames/sec; adaptability to the use of any 16-mm cine lens in a "C" mount.—*Beckman & Whitley, Inc., 973 E. San Carlos Ave., San Carlos, Calif.*

For more information circle **185** on inquiry card.

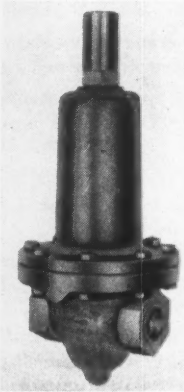
ELECTRONIC TRIGGER SWITCH

New Trigger Switch incorporates the recently introduced General Electric NE-77 special-purpose glow lamp which has a three-electrode structure, requiring no heater current.—*Drake Mfg. Co., 1711 W. Hubbard St., Chicago 22, Ill.*

For more information circle **186** on inquiry card.

PRESSURE REGULATOR

New Fig. 1910, Type E, Regulator of single-diaphragm, single-composition-seat construction is available in six sizes, from ½" to 2". Made of cast

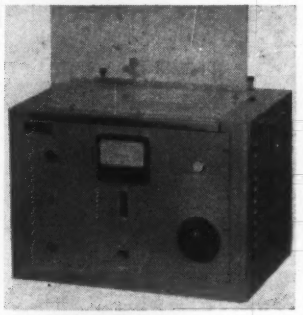


iron with bronze and steel trim it is designed for initial pressures to 300 psi with gas, oil, water, and outlet or regulated pressure spring ranges 5 to 35, 20 to 60 and 40 to 90 psi.—*Atlas Valve Co., 280 South St., Newark 5, N. J.*

For more information circle **187** on inquiry card.

INSULATION TESTER

New Model 4501 Automatic Insulation Materials Tester meets requirements of some 30 ASTM specifications for electrical insulating mate-



rials such as varnishes, paper, tape, glass, phenolics, and rubber in rods, tubes, sheets, etc.—*Associated Research, Inc.*, 3777 *West Belmont Ave., Chicago* 18, *Ill.*

For more information circle **188** on inquiry card.

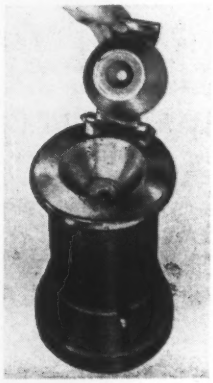
RF COAXIAL PLUGS

New lightweight RF coaxial AL Connector series utilizes aluminum shells, is 35% to 40% lighter in weight than comparable standard RF coaxials, and features an improved clamping mechanism which does not distort the cable dielectric.—*Cannon Electric Co.*, 3208 *Humboldt St., Los Angeles* 31, *Calif.*

For more information circle **189** on inquiry card.

WELL COUNTER

New well-type Scintillation Counter, Model SC-1, for research and medical use, designed to detect all levels of gamma radiation in prepared samples, has completely-transistorized preamplifier. A lead shield of less than



2-⅛" in all directions reduces background counts to approximately 200 counts per min. Sensitivity is such that as little as 10^{-5} microcuries of I-131 can be detected, with a counting efficiency of about 50%.—*Nuclear Measurements Corp.*, 2460 *N. Arlington Ave., Indianapolis* 18, *Ind.*

For more information circle **190** on inquiry card.

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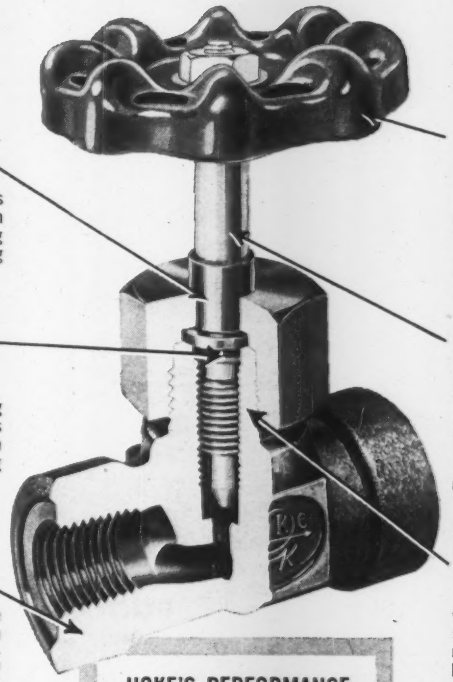
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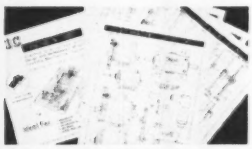

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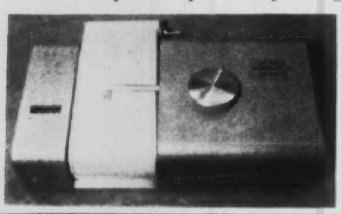
For more information circle **92** on inquiry card.

NEW INSTRUMENTS

STRIP CHART PLANIMETER

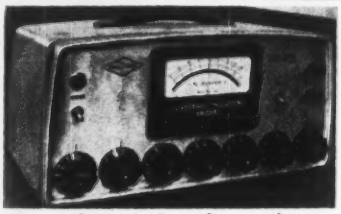
New portable Planimeter provides accurate integration of existing regular-size and 3" or 4" wide chart records. Conversion of the units from linear use to square root or visa versa is easily accomplished by changing a cam. Linear accuracy is said to be ½ of 1% while accuracy on square-root charts is ½ of 1% at the upper half of the scale and 1% at the lower end of the scale.—*Royson Engineering Co., Hatboro, Pa.*



For more information circle **191** on inquiry card.

RESISTANCE DEVIATION BRIDGE

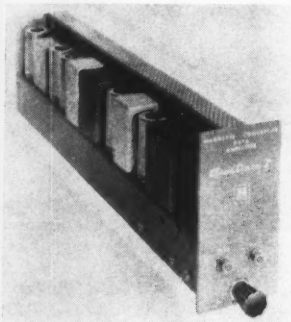
New transistorized Resistance Deviation Bridge, Model 158, indicates percentage deviation of a sample resistor from the standard resistor of the same nominal value. It uses a chopper-stabilized feedback amplifier in connection with a Wheatstone Bridge. Accuracy as a limit bridge is better than 0.05% for resistances greater than 10 ohms. Range is from 1 ohm to 10 megohms.—*Millitest Co. 88 Madison Ave., Hempstead, N. Y.*



For more information circle **192** on inquiry card.

DATA AMPLIFIERS

New d-c Amplifiers, AccuData I (Model 2HDH-61), and AccuData II (Model ISA-1), are for data-acquisition systems: AccuData I combines two second-harmonic magnetic con-



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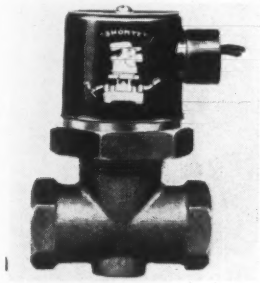
verters to provide ideal d-c transducer preamplifier characteristics and incorporates isolated differential input for strain-gage, thermocouple- and resistance-bridge measurements. It has frequency response to 100 cps. The output is single-ended to match emf-input analog-to-digital converters. AccuData II, completely transistorized and designed for wide-band differential amplification, high-frequency oscillograph, and tape-recorder applications, has current output to drive the high-frequency Visicorder Oscillograph.—*Minneapolis-Honeywell, Boston Div., 40 Life St., Boston 35, Mass.*

For more information circle **193** on inquiry card.

SOLENOID VALVE

New all-purpose two-way solenoid valve called the "Shorty" is rated 250 psi for air and gases, 150 psi water, 75 psi for oil, and 25 psi for

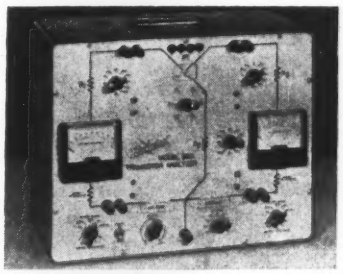


steam. Pilot-operated, the valve can be kept open with a minimum differential pressure of 5 psi. Available sizes are ¼", ⅜", ½", ¾".—*Atkomatic Valve Co., Inc., 545 W. Abbott St., Indianapolis 25, Ind.*

For more information circle **194** on inquiry card.

TRANSISTOR ANALYZER

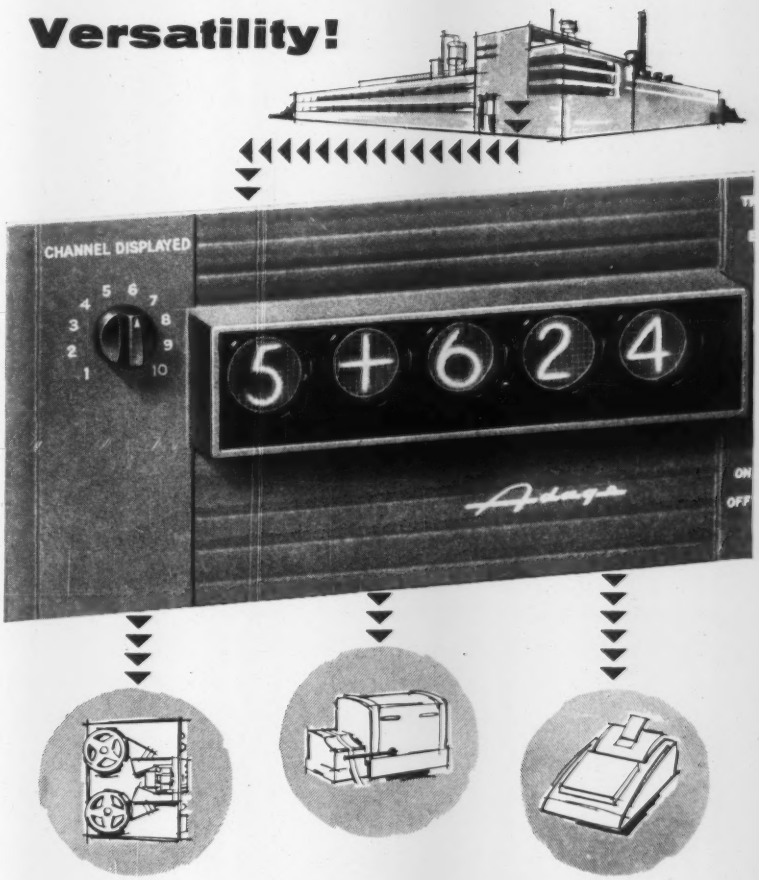
New low-cost Transistor Analyzer provides evaluation of a transistor to determine its ability to function under a specific circuit condition. Accuracy is limited only by the indicating



meters which are within ± 2% of full scale. It features a wide range of applied voltages available by substitution for "breadboard" configurations —Common Base, Common Emitter and Common Collector.—*Hickok Electrical Instrument Co., 10528 Dupont Ave., Cleveland 3, Ohio*

For more information circle **195** on inquiry card.

New Adage Converters Offer Unlimited Versatility!



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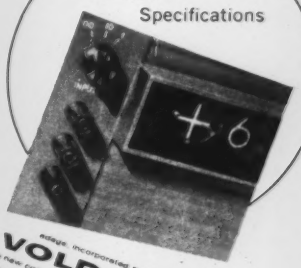

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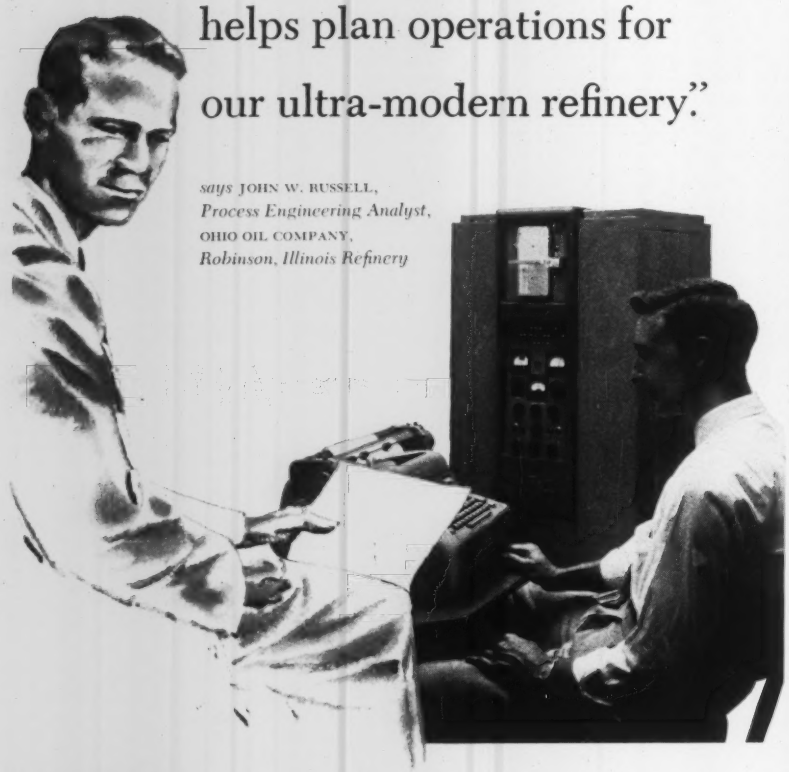
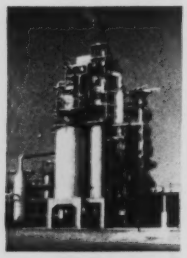
VOLDICON

For more information circle **93** on inquiry card.

"The Bendix G-15 computer helps plan operations for our ultra-modern refinery."



says JOHN W. RUSSELL,
Process Engineering Analyst,
OHIO OIL COMPANY,
Robinson, Illinois Refinery



"In the highly competitive oil industry, efficiently planned refinery operation is a must. To handle the complex mathematics involved in this planning, we needed the speed of electronic computing. After careful study, we have installed a Bendix G-15 and although it is one of the lowest priced machines, we are using it very successfully on large scale problems. We like the compact size and have found reliability to be exceptional. G-15 users share valuable programs through their own organization, too, and this adds materially to the computer's value."

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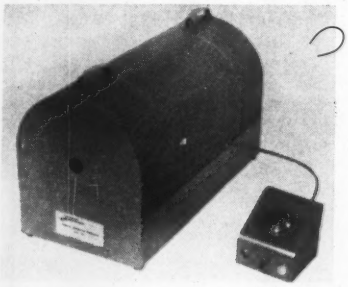
For more information circle **94** on inquiry card.

THERMAL RADIATION STANDARD

New Thermal Radiation Standard, Model 55, consists of a large-aperture isothermal cavity ("black body") and a transistorized temperature control circuit. Operating temperature range



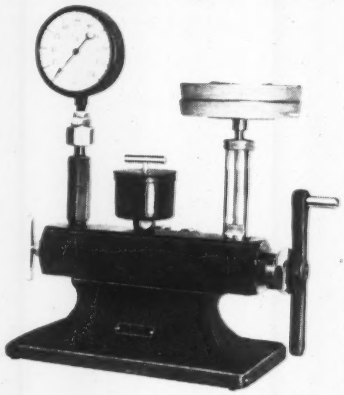
is from below 100°C to 1000°C. Temperature control is maintained within ±1°C. An effective total emissivity greater than 0.995 is accomplished through the use of a biconical cavity the walls of which have a uniformly high natural emissivity.—*Research Div., Electronic Communications, Inc., 1830 York Rd., Timonium, Md.*

For more information circle **197** on inquiry card.

VALVE POSITIONER

New Model J is a top-mounted integral Positioner capable of matching

AMTHOR Dead Weight Pressure Gauge TESTER



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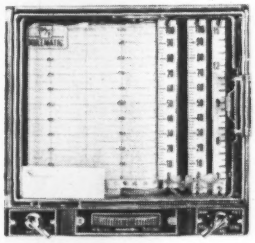
For more information circle **95** on inquiry card.

or exceeding speed and sensitivity of modern pneumatic controllers. Suitable for use on both cylinder- and diphragm-type actuators, it combines the proved force-balance design with a radically-new pilot-operated relay valve, providing high power output and maximum sensitivity. It is capable of an infinite number of stroke lengths up to 8" in any combination of control forms through a variety of models. Linearity is guaranteed to be better than 1% regardless of stroke length. The Model J responds to signal changes as low as 0.001 psi.—Bulletin J-1 gives detailed information.—*Conoflow Corp., 2100 Arch St., Phila. 3, Pa.*

For more information circle **198** on inquiry card.

CASCADE CONTROLLER

New single-station Cascade Controller with 4"-wide 31-day charts and scales for flow, temperature, pressure,

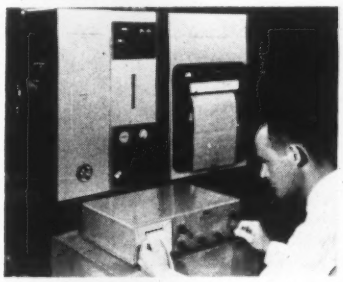


and other process variables, saves cost and panel space of a second station and greatly simplifies switching the controllers to cascade, automatic, or manual operation.—*Moore Products Co., H and Lycoming Sts., Phila. 24, Pa.*

For more information circle **199** on inquiry card.

CHROMATOGRAPHY ACCESSORY

New Model 194 Printing Integrator, provides automatically printed numerals of chromatographic chart peak area measurements on standard add-



ing-machine tape at a rate of up to 6000 counts per min, making it unnecessary for the analyst to record integrals. Although designed specifically for the Model 154-C Vapor Fractometer it can be easily adapted for use with other gas chromatography systems.—*Instrument Div., Perkin-Elmer Corp., Norwalk, Conn.*

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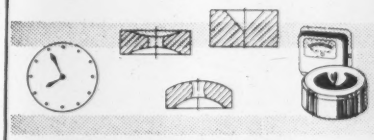

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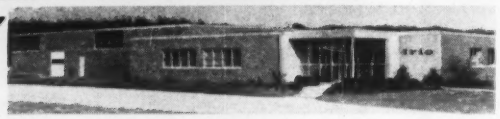
new plants and mergers



TRIO LABORATORIES announces its recent move to a new 16,000-sq-ft plant on a 2-acre site at Plainview, Long Island.

GENERAL PRECISION LABORATORY has opened a new 8000-sq-ft building in Pasadena, Calif.

McDANEL REFRACTORY PORCELAIN will concentrate in 1959 on specially made ceramic parts of components as a result of an R&D program carried on in conjunction with industry.

EPSCO'S Components Division has announced sale of its delay line and pulse transformer business to the *Eastern Precision Resistor Co.* after introduction of a new line of low-cost, encapsulated transistorized digital plug-in circuits.

THOMPSON RAMO WOOLDRIDGE INC. announces acquisition of a 90-acre site that will contain the new $10.5-million Ramo-Wooldridge Laboratories.

SERVO CORP. OF AMERICA will build a 120,000-sq-ft $1.5 million plant in Hicksville, Long Island.

BENDIX AVIATION, Computer Division, reports a 90% increase in electronic computer sales during fiscal 1958.

TEXAS INSTRUMENTS and **METALS & CONTROLS CORP.** have agreed in principle to recommend to their respective stockholders a merger of Metals & Controls into Texas Instruments.

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Thermotest is the all-purpose testing instrument for precise measurement of temperatures from −200°F. to +600°F., and emf's up to 20.1 millivolts. It's the only portable potentiometer with interchangeable direct reading scales *and* automatic compensation. Measurements are read directly from the scale without charts, graphs or conversion tables. Scales interchangeable in seconds for use with three types of thermocouples. Mercury battery power supply. Leatherette covered case. Dimensions: 12¼" x 9" x 8½". Weight: 14 lbs. Write for free bulletin.

TECHNIQUE

TECHNIQUE ASSOCIATES, INC.
POST OFFICE BOX 91
INDIANAPOLIS 6, IND.

For more information circle **100** on inquiry card.

DYNAMIC GEAR CO. Amityville, L. I., N. Y., has expanded into a newly opened additional plant in nearby Copiague.

JAS. P. MARSH CORP. and subsidiaries have been acquired by **COLORADO OIL & GAS CORP.**

SPLIT BALLBEARING a division of Miniature Precision Bearings, Inc., unveiled a new $600,000 plant at Lebanon, N. H. with a factory area of 34,000 sq ft.

people in the news

J. E. Degen

L. E. Butzman

DAYSTROM-WESTON divisions, Daystrom, Inc. have appointed *Joseph F. Degen* vice president—manufacturing.

ELGIN METALFORMERS CORP. have named *Lester E. Butzman, Jr.* sales manager.

WEKSLER INSTRUMENTS Corp's president E. P. Dobrin has announced election of *Alvin Marks* to executive vice-president.

MARSHALLTOWN

DIAPHRAGM GAUGE

FOR ACCURATE PRESSURE MEASUREMENT IN OUNCES OR INCHES OF WATER

Marshalltown Figure 83 is an extremely sensitive gauge that uses a carefully seasoned bronze diaphragm to accurately measure very low pressures. It is used extensively on many types of natural gas installations for checking low pressures.

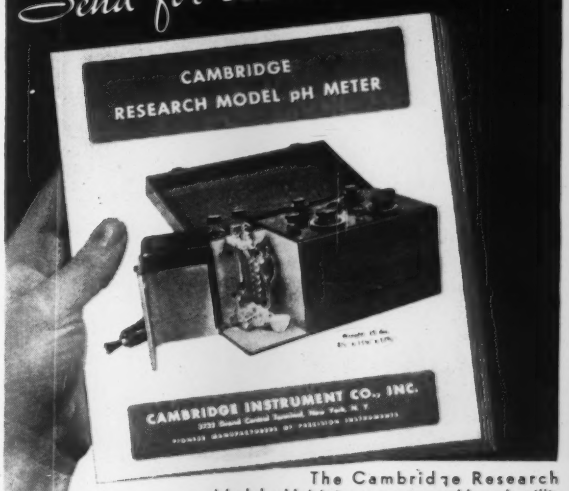
Available in standard dials (reading in inches of water) 0-15" -0-30" -0-60" -0-100" -0-160" . . . also in ounce graduated dials from 15 ounces to 5 pounds. 2½", 3½" and 4½" dial sizes mounted in black enameled steel case.

Write for details and price. LOOK TO MARSHALLTOWN FOR ONE OE THE MOST COMPLETE LINES OF INDICATING PRESSURE GAUGES MADE!

MARSHALLTOWN MFG. COMPANY
MARSHALLTOWN 3, IOWA

For more information circle **101** on inquiry card.

Send for **BULLETIN 911**



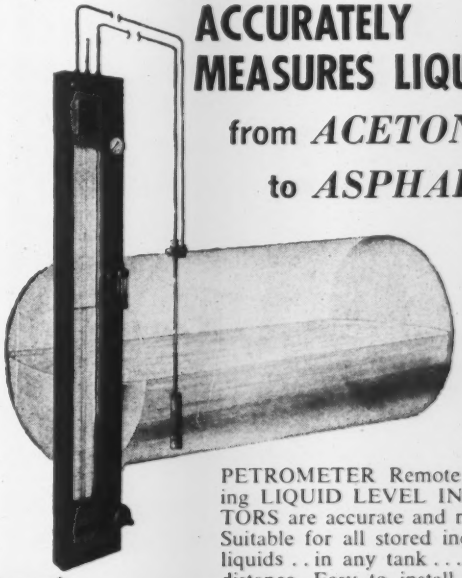
The Cambridge Research Model pH Meter measures pH and millivolt values where extreme precision and reliability are required. Although originally designed for biological and physiological use, the instrument is particularly useful in the Chemical, Pharmaceutical and Process Industries. The combination of features is not to be found in any other similar instrument.

CAMBRIDGE INSTRUMENT CO., INC.
3554 Grand Central Terminal, New York 17, N. Y.

PIONEER MANUFACTURERS OF PRECISION INSTRUMENTS

For more information circle **102** on inquiry card.

ACCURATELY MEASURES LIQUIDS
from *ACETONE* to *ASPHALT*



PETROMETER Remote Reading LIQUID LEVEL INDICATORS are accurate and reliable. Suitable for all stored industrial liquids . . in any tank . . . at any distance. Easy to install . . . and easy to read. Indicators have many unique design features.

write today for Bulletin 6004.

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CORPORATION
43-22 TENTH ST. LONG ISLAND CITY 1, N. Y.

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filters networks

Twin-T and other RC nets

Toroidal wave filters
high-pass, low-pass, band-pass

Active feedback filters

Complete engineering service offering prompt quotations on special problems

Fast delivery at competitive prices

Write for "Network Notes" and technical bulletins.

Plant at 5500 Balcones Trail

INSTRUMENT LABORATORIES
BOX 9006 AUSTIN 17, TEXAS

For more information circle **104** on inquiry card.

D. E. Teaford

W. Bein

F. P. Houpt

ROBERTSHAW-FULTON CONTROLS CO., Aeronautical and Instrument Div., has named *Dawson E. Teaford* sales manager, instruments, according to an announcement by R. H. Heller, general sales manager of the Division.

BURNELL & CO. has appointed *Walter Bein* director of engineering.

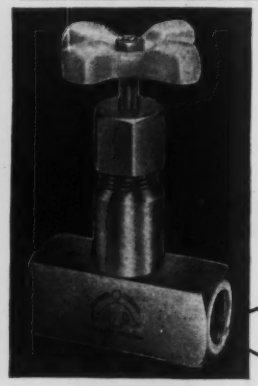
FISCHER & PORTER announces appointment of *Frank P. Houpt* as manager of the systems application engineering department.

MANNING, MAXWELL & MOORE has named *John F. Reed* and *Arland R. Walkley* vice presidents.

TEXAS INSTRUMENTS announced election of *E. O. Vetter*, general manager of the Industrial Instrumentation division, as an assistant vice president of Texas Instruments Incorporated.

D. S. HARDER who was executive vice president—basic manufacturing divisions of *Ford Motor Company* retired last month at the age of 66. He invented the word "automation."

PARKER-HANNIFIN CORP. has announced promotions in the Parker Seal Company Division: *Paul F. Smith*, becomes president, *Scott A. Rogers* vice president, and *T. J. McCuistion* vice president, sales.

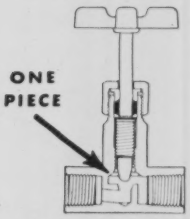


MARSH
Needle Valves

MAXIMUM WORKING PRESSURE 10,000 PSI

. . . for finer regulation of water, oil or gas

First needle valve to combine all the characteristics called for in modern industry. Embodies sturdiest basic construction—machined from solid bar stock—suitable for pressures to 10,000 psi and equally efficient in lower range. Note stem guide fused to body by new "Conoweld" process, eliminating faults of conventional two-piece valves. Stem 416 stainless steel. Stem threads fine pitch for strength and micrometer regulation. Body electro-zinc plated. Sizes ⅛" to 1", globe and angle patterns.



Ask for new Needle Valve Catalog

MARSH INSTRUMENT CO. *Sales Affiliate of Jas. P. Marsh Corp.* **Dept. 42, Skokie, Ill.**
Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd Street, Edmonton, Alberta, Canada

For more information circle **105** on inquiry card.

A simple, direct reading on the Alnor Velometer gives you an instant measure of air flow speed through grilles, ducts, furnaces, spray booths, or in the open.

Precision-built and self-contained, this portable instrument brings laboratory standards to the line or field installation. Available in a wide variety of scale ranges, full assortment of jets and fittings. You'll want all the facts (no safety department should be without a Velometer). Get Bulletin 2448-G. Attach this ad to your letterhead and mail to: Illinois Testing Laboratories, Inc., Room 518, 420 No. LaSalle St., Chicago 10, Illinois.

PRECISION INSTRUMENTS FOR EVERY INDUSTRY

Alnor

For more information circle **106** on inquiry card.

ELECTRONIC ASSOCIATES' expansion in 1958 is reflected by the move into a new 60,000-sq-ft manufacturing plant in West Long Branch and the creation of four

new vice-presidents. Shown in picture of (l. to r.): *L. F. Christianson,* president; *R. R. Favreau,* vice president, computation centers; *F. L. Martinson,* vice president, engineering; *A. L. Adamson,* executive vice president; *C. J. Marsh,* vice president, sales; and *R. C. Higbee,* vice president, manufacturing operation.

THE BRISTOL COMPANY announces appointment of *Harry E. Beane, Jr.,* as sales engineer in Schenectady, serving the Albany-Syracuse area, and appointment of *John F. Peterson* as manager of the Newark Branch Office.

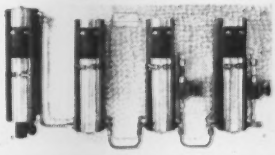
GENERAL PRECISION EQUIPMENT CORP. has elected a first vice president and four new corporation vice presidents: *R. N. Harder* becomes first vice president and treasurer; *D. W. Smith,* president of Kearfott, and *D. D. Mason,* president of Link Aviation become group vice presidents; *J. W. Murray,* president of General Precision Lab. has been elected vice president-financial of the parent company; *L. W. Imm,* president of Librascope becomes a General Precision vice president; and *F. D. Herbert, Jr.,* a General Precision vice president, already has similar responsibilities for subsidiary operations in the Eastern United States.

LEAK PROOF VALVES . . .
Replaceable Soft Seat
Metering or Flow

HI-VACUUM TO 6,000 PSI
PNEUMATIC *HYDRAULIC*
ANGLE — GLOBE — THREE PORT — MANIFOLD

ROBBINS Aviation, Inc.
2350 E. 38th St. - Los Angeles 58, Calif.

DEHYDRATION



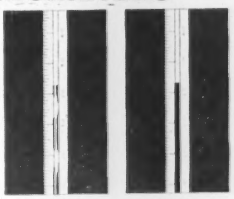
Remove moisture & oil vapor from gases with working pressures up to 12,000 PSI; dewpoint —100°F.

For more information circle **108** on inquiry card.

NOW...

QUICK, CLEAR READINGS ON BLACK-READING, WHITE-BACK MERCURY THERMOMETERS

All the advantages of mercury are now combined with the clear visibility of black-on-white. On new QUIKSITE thermometers you can take fast, reliable temperature readings without the confusing reflections normally associated with mercury.



ORDINARY MERCURY THERMOMETER Silvery thread reflects confusing external images.

QUIKSITE MERCURY THERMOMETER Sharp black-reading thread instantly visible.

With black-reading QUIKSITE the image is clear and sharp—black against white—no reflections, no glare, no errors. Send for Catalog 19-A, describing hundreds of H-B precision instruments. H-B Instrument Co., 4302 N. America Street, Philadelphia 40, Pa.

ANOTHER H B *FIRST!*

QUIKSITE BLACK-READING MERCURY THERMOMETERS

For more information circle **107** on inquiry card.

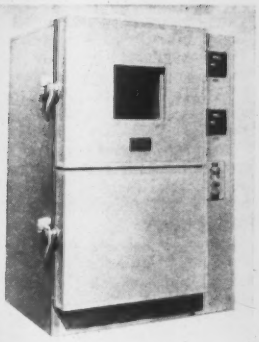
CREATING ENVIRONMENT

- HOT
- COLD
- HUMIDITY

AT LOW COST

USES DRY ICE FOR LOW TEMPERATURES AND NICHROME WIRE HEATERS FOR HIGH TEMPERATURES.

From Minus 90° F to Plus 240° F



2 x 2 x 2 Vertical Laboratory Model

DEVELCO

DEVELOPMENT ENGINEERING COMPANY, INC.

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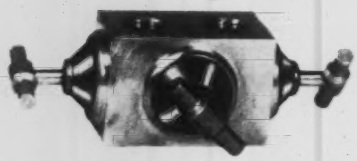
• Manufacturers of Environmental Test Equipment
Fungus - Cold - Heat - Altitude - Humidity - Salt Spray

For more information circle **109** on inquiry card.

MINIATURE MANIFOLDS

for

Multi-Purpose CONTROL



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"DEMI" M2 SERIES

All models of the standard Dahl "Demi" M2 series of three-valve manifolds are readily adaptable to clean liquid, gas and vapor applications. The size of these manifolds makes them especially suitable for pilot plant, aircraft and marine applications, flow control and automation. They are miniature in size, yet their patented form for bubble-tight shutoff makes them comparable to much larger valves in performance.

These manifolds consist of two block valves and one bypass valve in place of 3 separate valves . . . they eliminate two tees, four nipples and eight threaded connections. Models of the "Demi" M2 series come in a variety of barstock materials and may be ordered with special features such as: bolted bonnets, swaged-in TEFLON seats, toggle actuators, etc.

PRESSURE RATING Metal Body & Diaphragm Neoprene Diaphragm	 750 psi at 450°F 100 psi at 180°F
MAXIMUM Cv	0.4
CONNECTIONS	1/16", 1/8", 1/4" N.P.T.

Send for the "DEMI" Catalog D-1 and other technical data on Dahl pneumatic and hydraulic valves.

GEORGE W.
DAHL
COMPANY, INC.

86 TUPELO STREET, BRISTOL, RHODE ISLAND

For more information circle **110** on inquiry card.

new literature

CONTROL SYSTEMS

AUTOMATIC CONTROL SYSTEMS. 8-page Brochure F8944 is a guide for designing and planning an automatic control system for most types of heating, ventilating and air conditioning installations.—Barber-Colman Co., 1300 Rock St., Rockford, Ill.

For more information circle **201** on inquiry card.

CONTROL PANEL ACCESSORIES. 4-page Bulletin 104 describes 5 accessories for use with control panel information systems.—Panellit, Inc., 7401 No. Hamlin Ave., Skokie, Ill.

For more information circle **202** on inquiry card.

VALVES

CUSHIONED VALVES. 8-page Bulletin G-5A describes with schematic drawings and actual installation pictures applications of water valves for level control, relief, pressure regulation, etc.—Golden Anderson Valve Specialty Co., 1232 Ridge Ave., Pittsburgh 33, Pa.

For more information circle **203** on inquiry card.

PRESSURE REDUCING REGULATOR. 2-page catalog sheet describes new Fig. 1910, Type E, reducing valve for initial pressures to 300 psi with gas, oil or water.—Atlas Valve Co., 280 South St., Newark 5, N. J.

For more information circle **204** on inquiry card.

NEEDLE VALVE. 4-page catalog describes N-20 globe-type needle valve for high-pressure service in industry, utilities, pipe lines, chemical plants, oil refineries, and petro-chemical service.—Kerotest Mfg. Co., 2525 Liberty Ave., Pittsburgh 22, Pa.

For more information circle **205** on inquiry card.

SOLDER-JOINT VALVES. 4-page Bulletin 581 describes line of solder-joint valves for copper tubing installations. These valves are designed for modern piping systems and are for use with types K. L. and M. copper tubing.—The Kennedy Valve Mfg. Co., Elmira, N. Y.

For more information circle **206** on inquiry card.

PROCESS INSTRUMENTATION

TEMPERATURE CONTROLS. 4-page folder Form 1086 describes applications of temperature controls in the plating room.—Partlow Corp., New Hartford (Utica), N. Y.

For more information circle **207** on inquiry card.

ENCASED THERMOCOUPLES. 4-page Bulletin 3A describes, illustrates and lists sheathed Trinox thermocouples encased in inert metallic oxide.—Trinity Equipment Corp., Cortland, N. Y.

For more information circle **208** on inquiry card.

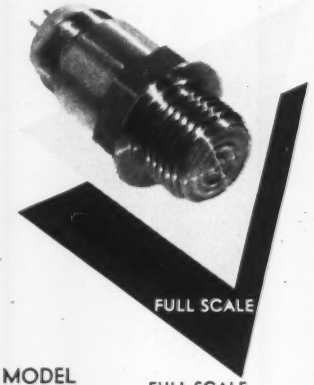
THERMOSTAT METALS. 4-page Bulletin TRU-8 provides graphical solutions for first sample determinations of simple beams, cantilever beams, special and helix coils and U-shapes.—Metals & Controls Corp., General Plate Div., Attleboro, Mass.

For more information circle **209** on inquiry card.

Dynisco

Thermally Insulated

PRESSURE TRANSDUCER



MODEL PT 61 FULL SCALE

Incorporates Unbonded Strain Gauge

HIGHLIGHTS

► WELDED FLUSH-MOUNTED DOUBLE DIAPHRAGM

► MAXIMUM OUTPUT TRANSIENT DUE TO SUDDEN DIAPHRAGM TEMPERATURE CHANGE OF 100°F IS LESS THAN 2% OF FULL OUTPUT

► NON-LINEARITY LESS THAN ½%

► MINIATURE SIZE

PRESSURE RANGES
0-250 to 0-1500 psi

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For more information on Dynisco pressure, force, flow, and displacement pickups,

write:

DYNAMIC INSTRUMENT CO.
42 Carleton Street
Cambridge 42, Mass.
UN 4-7260

For more information circle **111** on inquiry card.

PRESSURE GAGES. 36-page Catalog DH-65 describes and illustrates the newly designed Safe-T-Case Gage for severe or dangerous services.—Helicoid Gage Div., American Chain & Cable Co., Inc., Bridgeport 2, Conn.
For more information circle **210** on inquiry card.

BATCHING SYSTEMS. 8-page brochure Form 2964 describes latest product developments of batching controls.—Toledo Scale, Div. of Toledo Scale Corp., Toledo 12, Ohio
For more information circle **211** on inquiry card.

PUNCHED CARD READER. 2-page Bulletin NP-2 describes automated batching with pre-punched cards.—Richardson Scale Co., Van Houten Ave., Clifton, N. J.
For more information circle **212** on inquiry card.

PROPORTIONING PUMPS. Catalog 100 provides detailed description of new Series 100 proportioning pumps. Also contains information on chemical feed pump-tank "package system".—American Meter Co., Pump Div., 13500 Philmont Ave., Phila. 16, Pa.
For more information circle **213** on inquiry card.

LIQUID LEVEL GAGES. 8-page Catalog 338 covers line of Truscale gages for remote liquid level indication for boilers, deaerating vessels, boiler feed water tanks, storage tanks, etc.—Jerguson Gage & Valve Co., Adams St., Burlington, Mass.
For more information circle **214** on inquiry card.

CHLORINATOR. 4-page issue of "Topics", Vol. 12, No. 1, contains articles on V-notch Chlorinator, precision pressure instruments, chemical feeder, etc.—Wallace & Tiernan, Inc., 25 Main St., Belleville 9, N. J.
For more information circle **215** on inquiry card.

WATER DEMINERALIZER. 6-page bulletin illustrates and describes ion-exchange water demineralizers for industrial and laboratory use.—Enley Products, Inc., 1236 Broadway, Brooklyn 21, N. Y.
For more information circle **216** on inquiry card.

TIME

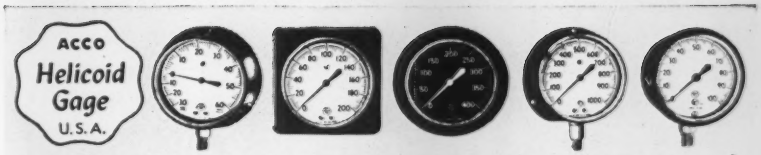
DIGITAL DELAY GENERATOR. 4-page Bulletin 4884 details full specs and data on Model 218A for precision time measurements.—Hewlett-Packard Co., 4884 Page Mill Rd., Palo Alto, Calif.
For more information circle **217** on inquiry card.

TIMER KIT. 2-page Bulletin 201 illustrates and describes Series MCK synchronous-motor-driven Multi-Cam kit for experimental work.—Industrial Timer Corp., 1407 McCarter Highway, Newark 4, N. J.
For more information circle **218** on inquiry card.

NUCLEONICS

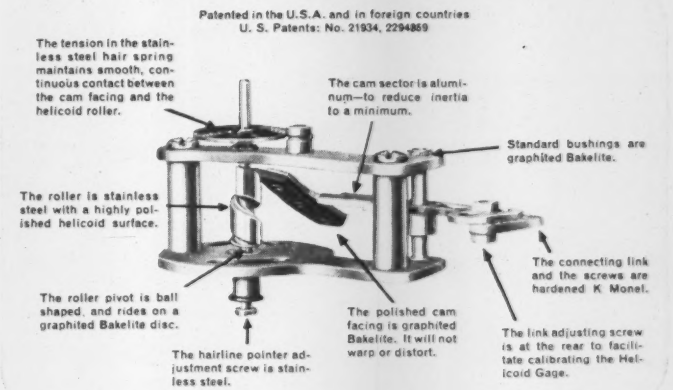
RADIATION DETECTORS. 48-page catalog contains information on 19 alpha, beta, gamma detectors and accessories.—Anton Electronic Laboratories, Inc., sub. of United States Hoffman Machinery Corp., 1226 Flushing Ave., Brooklyn 37, N. Y.
For more information circle **219** on inquiry card.

MAGNETIC-AMPLIFIER SYSTEMS. 8-page Bulletin S-963 describes among other magnetic-amplifier systems the rod programmer amplifiers designed



Nothing but the best in gages for working pressures from 30" vacuum to 10,000 p.s.i.

These details of Helicoid gage design assure longer life and enduring accuracy


Patented in the U.S.A. and in foreign countries
U. S. Patents: No. 21934, 2294859
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is aluminum—to reduce inertia to a minimum.
Standard bushings are graphited Bakelite.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped, and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

The superiority of Helicoid Gages is most evident in severe service—wherever a gage is subjected to violent pressure pulsations or severe mechanical vibrations.

The *sustained accuracy* of Helicoid Gages over *millions of cycles* is explained by the details of design and construction of the Helicoid movement shown above. Such Helicoid features—protect against wear and corrosion and assure sensitivity, sustained accuracy and trouble-free operation.

The Chemical Gage

The Helicoid Chemical Gage has a guaranteed accuracy of plus or minus 1%. It is applicable for working pressures from 30" vacuum to 5000 p.s.i. and temperatures to 400° F. It is particularly suitable for chemicals and other viscous fluids which might clog or corrode a Bourdon tube. Pressure and/or vacuum is transmitted directly to the indicating gage element through deflection of a Teflon or Kel F sealing diaphragm.

Tubes built for millions of pressure pulsations

To fit the wide range of applications, Helicoid Bourdon tubes are available in four materials—alloy steel, K Monel, stainless steel and phosphor bronze.

All Helicoid tubes are made from seamless tubing and are carefully designed to give maximum torque and minimum stress. When used within the dial range, they will withstand many millions of pressure pulsations and will not stretch, leak or crack.

For complete information on the Helicoid line of gages write for **Catalog G-52**

Helicoid gives you all these features at prices that are competitive in the quality gage field.

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AMERICAN CHAIN & CABLE

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ACCO
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For more information circle **112** on inquiry card.

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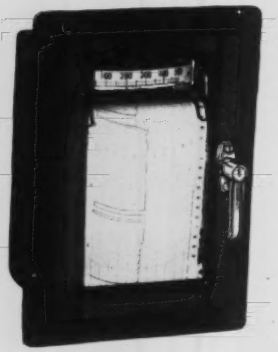

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For more information circle **113** on inquiry card.

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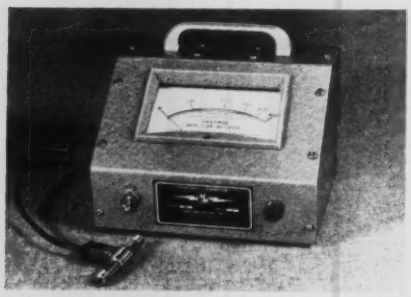
MASS FLOWMETER

For Air and Gases

DIRECT READINGS INDEPENDENT OF PRESSURE AND TEMPERATURES

Calibrated directly in milligrams of air per minute. Especially well suited for measuring low rates of flow. Gives direct, continuous readings, holds calibration indefinitely, has low power requirements.



Hastings Model SM-1 Mass Flowmeter
Range: 0 - 500 milligrams of air per minute

HASTINGS MODEL SM-1 MASS FLOWMETER
Range: 0 - 500 milligrams of air per minute. Relatively linear scale. Large mirror scale assures highest accuracy and easier readability. Ideal for remote indicating recording.

HASTINGS MODEL MF-1 MASS FLOWMETER
Range: 0 - 10,000 milligrams of air per minute. Highest accuracy and sensitivity at low flow ranges. Maximum readability for air flows in range from 50 - 1,000 milligrams per minute.

COMPLETE LINE OF INDUSTRIAL, COMMERCIAL, AND LABORATORY INSTRUMENTS.
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VACUUM AND PRESSURE GAUGES

HASTINGS-RAYDIST, INCORPORATED
HAMPTON 53, VIRGINIA

For more information circle **114** on inquiry card.

NEW LITERATURE

for the nuclear electric power plant at Shippingport, Pa.—Magnetic Amplifiers, Inc., 632 Tinton Ave., New York 55, N. Y.

For more information circle **220** on inquiry card.

RADIATION METERS. 8-page bulletin, Form 3044B, describes portable radiation survey meters.—Victoreen Instrument Co., Instruments Div., 5806 Hough Ave., Cleveland 3, Ohio

For more information circle **221** on inquiry card.

TESTING

TESTING INSTRUMENTS. 4-page "Instrument News", Vol. 14, No. 3, contains information on Frahm speed indicator, insulation tester with Wheatstonebridge testing unit, etc.—James G. Biddle Co., 1316 Arch St., Phila. 7, Pa.

For more information circle **222** on inquiry card.

TESTING FACILITIES. 6-page Bulletin 5801 describes the complete line of laboratory and field testing facilities and services available from United States Testing Company, Inc., 1415 Park Ave., Hoboken, N. J.

For more information circle **223** on inquiry card.

DATA HANDLING

DIGITAL SUBTRACTOR. 2-page Technical Bulletin 101 describes design features and operating characteristics of Model DS-12-A digital subtractor/converter unit that compares two input signals which consist of digital pulses, subtracts one from the other digitally, and presents an analog output signal.—Computer Equipment Corp., 1931 Pontius Ave., Los Angeles, Calif.

For more information circle **224** on inquiry card.

ANALOG TECHNIQUE. 4-page folder "The Lightening Empiricist," Issue No. 6, contains information on applications, techniques, and new or improved components in the field of analog computation.—George A. Philbrick Researches, Inc., 285 Columbus Ave., Boston 16, Mass.

For more information circle **225** on inquiry card.

DATA-PROCESSING SYSTEMS. 6-page booklet U1395 describes features of new Univac II computer with high-speed magnetic-core memory.—Remington Rand Div. of Sperry Rand Corp., 315 Fourth Ave., New York 10, N. Y.

For more information circle **226** on inquiry card.

DATA LOGGERS for weight, strain, force, flow, pressure, and temperature are described in 4-page brochure.—Gilmore Industries, Inc., 13015 Woodland Ave., Cleveland 20, Ohio

For more information circle **227** on inquiry card.

MAGNETIC TAPE. 4-page Bulletin 36 discusses the merits of a new precision tape reel.—Minnesota Mining and Mfg. Co., Dept. E8-376, 900 Bush St., St. Paul 6, Minn.

For more information circle **228** on inquiry card.

ANALYTICAL, LABORATORY

SELECTIVE GAS ANALYSIS. 4-page Bulletin 0716-2 contains specifications, typical schematic wiring dia-

grams, operational details and other information about the new M-S-A Thermatron for selective analysis of one component of a complex gas mixture.—Mine Safety Appliances Co., 201 North Braddock Ave., Pittsburgh 8, Pa.

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INTERFEROMETERS. 8-page Brochure 140-58 outlines the theory of dilatation measurements and discusses the use of dilatation interferometer dental interferometer and quartz-tube dilatometer.—Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago 14, Ill.

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GAS CHROMATOGRAPHY. 18-page Application Data Sheet GC-90-MI lists the characteristics of 22 chromatographic columns along with their important applications, and includes 28 chromatograms demonstrating actual column performance.—Beckman/Scientific and Process Instruments Div., 2500 Fullerton Rd., Fullerton, Calif.

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ELECTRICAL, ELECTRONIC INSTRUMENTS

DIGITAL VOLTMETER. 2-page Data Sheet 19-24 describes Model 402 digital voltmeter with built-in ac converter.—Kin Tel, a div. of Cohu Electronics, 5725 Kearny Villa Rd., San Diego 12, Calif.

For more information circle **232** on inquiry card.

X-Y INDICATOR. 2-page bulletin describes technical features of Model 1002 cathode ray indicator.—Technitrol Engineering Co., 1952 E. Allegheny Ave., Phila. 34, Pa.

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AMPLIFIERS. 4-page Bulletin 105801 gives technical data on Models DA-102 and DA-112 low-level wide-brand d-c amplifiers.—Epsco, Inc., 588 Commonwealth Ave., Boston, Mass.

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CAPACITANCE. 8-page issue of "Experimenter", Vol. 32, No. 18, contains articles on "1-Mc Capacitance Measuring Assembly", "Automatic Capacitance Bridge", "Variable Air Capacitor", etc.—General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

For more information circle **235** on inquiry card.

DIGITAL VOLTMETER. Bulletin 3018 describes the Model 81 digital voltmeter. Contains information on operation, circuitry, and specifications, applications and accessories.—Beckman/Systems Div., 325 North Muller Ave., Anaheim, Calif.

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VOLTAGE REGULATOR. 6-page Bulletin 6.04 describes new 60-finger regulator for direct control of voltage of main fields of large alternators and generators; line road regulation; power amplification; impedance matching; and system stabilization.—Electric Regulator Corp., Pearl St., Norwalk, Conn.

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SWITCHGEAR. 24-page Bulletin 2804-1A describes in detail line of 4160-

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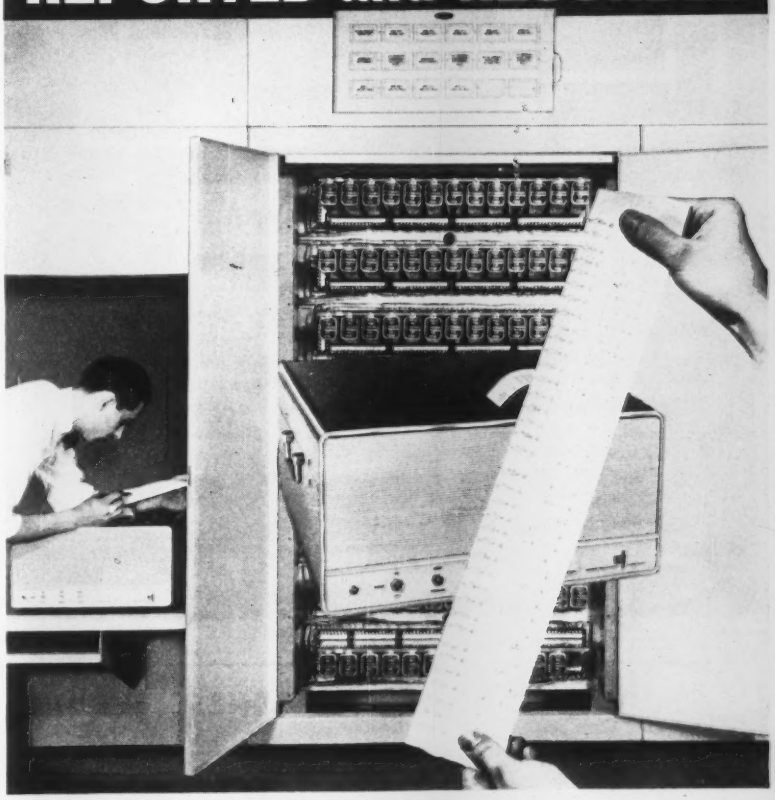

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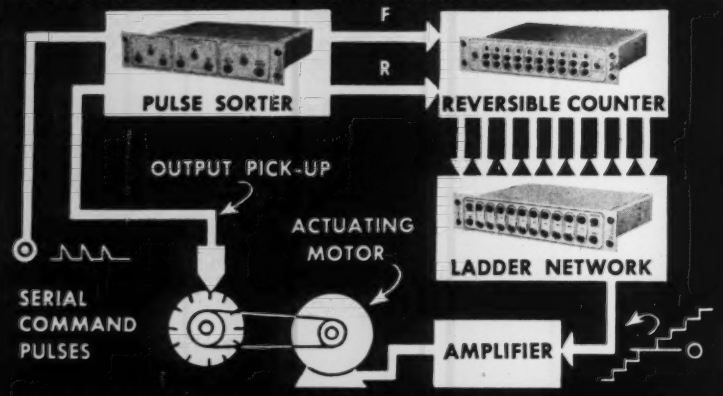

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NEW LITERATURE

volt metal-clad switchgear.—I-T-E Circuit Breaker Co., 1900 Hamilton St., Phila. 30, Pa.
For more information circle **238** on inquiry card.

MAGNETIC VOLTAGE REGULATORS. 4-page product data sheet illustrates and provides details curves and diagrams.—Sorensen & Company, Inc., Richards Ave., South Norwalk, Conn.
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RECORDERS

DEMAND RECORDER. 16-page Catalog 35A1000 describes digital demand recorder, an impulse counting and recording device for electric utility customer billing, load survey studies, production control, traffic counting, and atomic energy work.—Fischer & Porter Co., 828 Jacksonville Rd., Hatboro, Penna.
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END POINT RECORDER. 4-page Bulletin 703 describes this automatic instrument which determines and records the end point (maximum temperature attained during distillation test) of a hydrocarbon mixture.—Precision Scientific Development Co., Div. of Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.
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OPTICAL

OPTICS FOR INDUSTRY. 96-page Catalog 589 lists hundreds of quality control aids—measuring magnifiers, many types of microscopes, pocket comparators, illuminators, projection sets, etc.—Edmund Scientific Co., Barrington, N. J.
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RECORDING MICROPHOTOMETER. 4-page bulletin describes Model D-B2 which permits investigations of all types of photographs from x-ray diffraction film to spectroscopic plate.—Wihtol Industries, Lewis St., Eatontown, N. J.
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ELECTRICAL, ELECTRONIC COMPONENTS

ELECTRONIC COMPONENTS. 8-page Catalog, Vol. 1, No. 15, contains descriptions and lists of tubes, transistors, amplifiers, generators, hi-fi components, etc.—Lectronic Distributors, 727 Arch St., Phila. 6, Pa.
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THERMOPLASTIC KNOBS. 6-page catalog illustrates and describes thermoplastic knobs which are available in polystyrene and acetate.—Waterbury Companies, Inc., 563 Washington St., Waterbury 20, Conn.
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POTENTIOMETERS. 4-page Brochure 4 summarizes information on lead-screw-actuated potentiometers, listing available resistances, terminal types, end settings, power ratings, etc.—Bourns Laboratories, Inc., P. O. Box 2112, Riverside, Calif.
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WIRE WOUND POTS. Two 2-page Data Sheets briefly describe Model-

830-series 3-turn, and Model-800-series multiturn precision potentiometers.—Spectrol Electronics Corp., 1704 South Del Mar Ave., San Gabriel, Calif.

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CERAMIC MATERIALS. 16-page Handbook describes the mechanical, electrical, and environmental characteristics of Centralab engineered ceramics.—Centralab, 900 East Keefe Ave., Milwaukee 1, Wis.

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STRIP TERMINALS. 12-page Catalog K1958 lists, illustrates and explains uses of strip terminals.—Kent Mfg. Corp., 188 Needham St., Newton, Mass.

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CERAMIC DISC CAPACITORS. 6-page folder "The Ultimate in Reliability . . . El-Menco Ceramic Disc Capacitors are the Toughest" includes specifications data, charts and graphs on the performance capabilities of ceramic-disc capacitors.—Electro Motive Mfg. Co., Inc., Willimantic, Conn.

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CONNECTORS. 12-page issue of "Cannonade", Vol. 10, No. 6, describes 9 new plugs developed in 1958, and contains articles on aluminum oxide insulation, snap-in contacts, and applications of solar energy.—Cannon Electric Co., P. O. Box 3765, Terminal Annex, Los Angeles 54, Calif.

For more information circle **251** on inquiry card.

HI-TEMP CONDUCTORS. 2-page Bulletin P-10 contains technical information on plated and clad copper wire.—Sylvania Electric Products, Inc., Parts Div., Warren, Penna.

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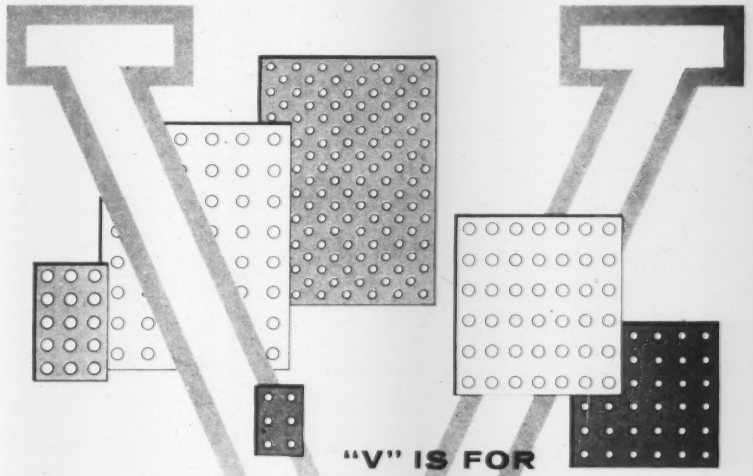

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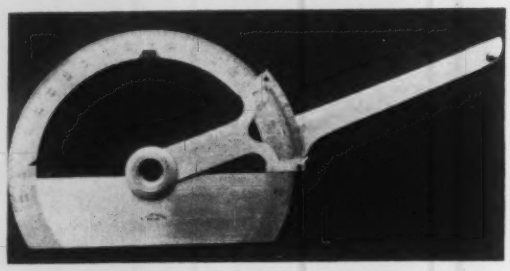

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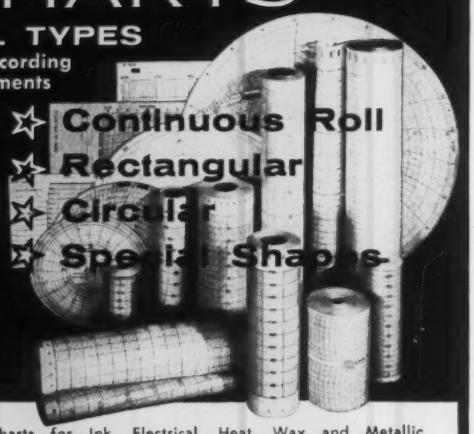

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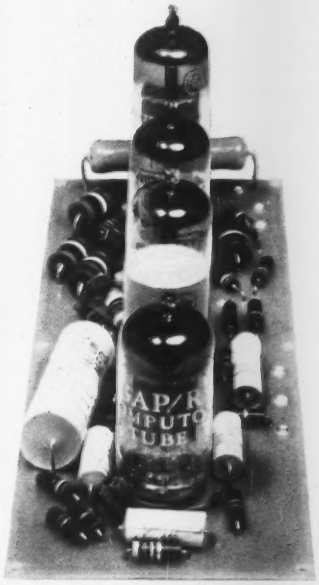

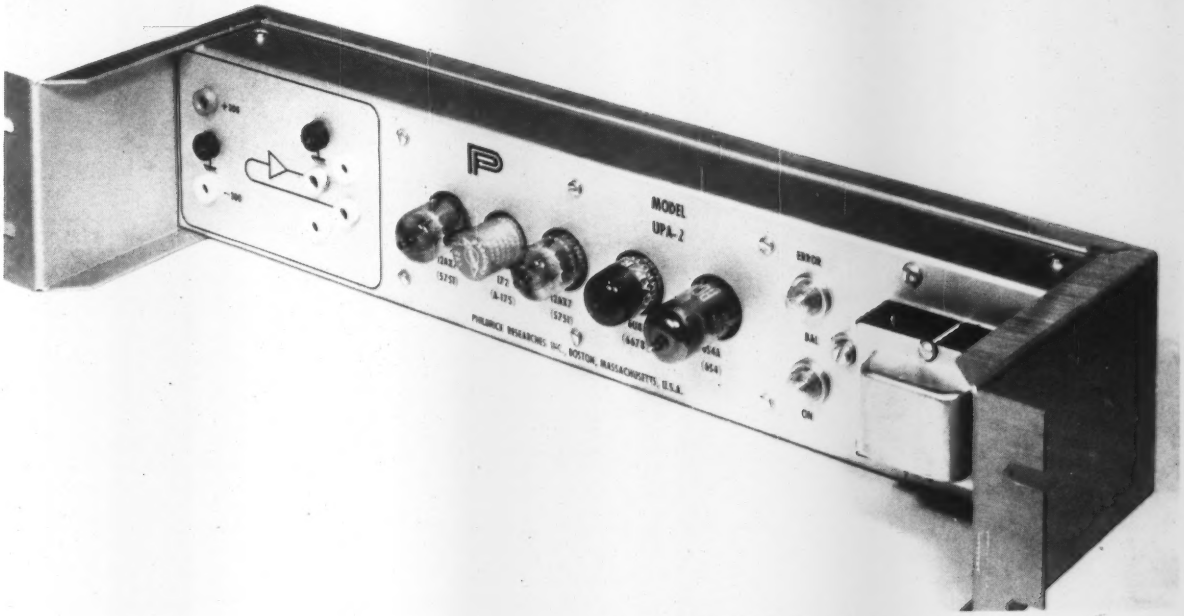

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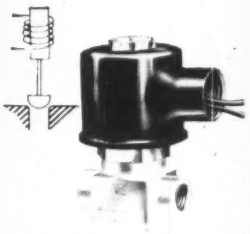

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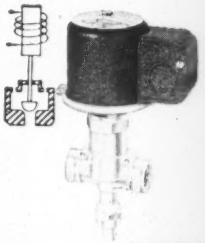

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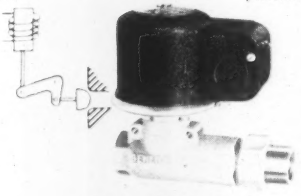

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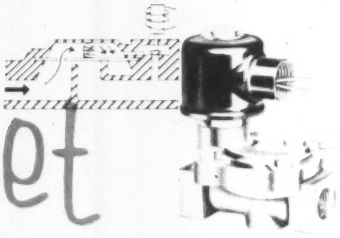

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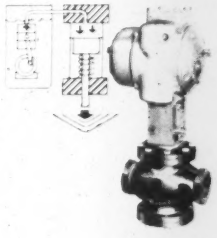

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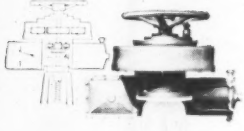

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